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# AN APPROACH TO A RELATIVE TROPHIC INDEX FOR CLASSIFYING LAKES AND RESERVOIRS (A PRELIMINARY ANALYSIS OF NATIONAL EUTROPHICATION SURVEY DATA COLLECTED DURING THE 1972 SAMPLING PERIOD)

Pacific Northwest Environmental Research Laboratory

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# AN APPROACH TO A RELATIVE TROPHIC INDEX SYSTEM FOR CLASSIFYING LAKES AND RESERVOIRS

WORKING PAPER NO. 24

A Preliminary Analysis of
National Eutrophication Survey Data
Collected During
the 1972 Sampling Period

National Eutrophication Survey
Pacific Northwest Environmental Research Laboratory
Corvallis, Oregon
December, 1974

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16. ABSTRACT

A relative trophic state index for lake classification was developed using six key water quality parameters. The data base was approximately 200 lakes and reservoirs in northeast and north central United States which had been included in the National Eutrophication Survey during 1972-73. Each lake was given an index number and was also classified according to the conventional terminology of oligotrophic, mesotrophic, and eutrophic. The method can be used to classify a lake of unknown trophic condition if the proper parameters have been measured.

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17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| eutrophication<br>lakes<br>reservoirs<br>enrichment<br>oligotrophy<br>mesotrophy<br>eutrophy | National Eutrophication Survey | 05B<br>05C |

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# FORWARD

The Trophic State Index discussed in this report is not proposed as the final answer to determining the trophic condition of lakes and reservoirs; and there were, in fact, some reservations by the Survey staff about making this paper available for public distribution. The method described herein, however, has been useful to the Survey for categorizing each water body according to trophic condition and is therefore offered for whatever value it might have to others interested in evaluating trophic conditions of lakes and reservoirs.

## INTRODUCTION

One of the major tasks confronting the staff of the National Eutrophication Survey is the assessment of the trophic condition of the water bodies studied. Many of these waters previously have been studied only superficially, if at all, and the Survey data provide the only basis for the evaluation of trophic condition.

In addition, Section 314(a) of Public Law 92-500 requires that each State classify, according to trophic condition, each of its publicly owned waters. The question, of course, is which classification system or index system to use. The Environmental Protection Agency (EPA) also wants an index or indices which can be used to evaluate changes in water quality over a period of time to determine whether conditions have improved or deteriorated.

Therefore, from the beginning of the Survey, it was apparent that there was a need for a lake classification system, based on Survey data, from which the trophic condition of the Survey lakes could be better defined and which also had some utility to the States in classifying other lakes not included in the Survey.

The intent of the approach used by the Survey is to provide a numerical trophic index which will permit a more realistic assignment of trophic condition then the relatively inflexible categorizations of oligotrophic, mesotrophic, eutrophic, or hypereutrophic. It is apparent, particularly when working with a large group of lakes, that trophic condition is a

continuum with no sharp demarcations as are suggested by the traditional classes and the trophic index utilized in this paper demonstrates that.

INDEX DEVELOPMENT

The development of an index or lake classification system is not a new consideration in the limnological community. In perusing the literature, it quickly becomes evident that "the most striking feature of limnological classifications is not the difficulty of producing some sort of arrangement, but the multiplicity of arrangements that have been proposed" (Sheldon, 1972). However, guided by a desire to devise a method that could be used by those with little or no knowledge of the more complex and sophisticated tools of statistical analyses (for some of which large-scale computer capability is a necessity), our first effort was a variation of a relatively simple ranking method used by Lueschow, et al. (1970) for 12 Wisconsin lakes. Using the unweighted mean annual values of selected physical, chemical and biological parameters-- each of which in one way or another reflect the trophic condition of a lake, Lueschow, et al. derived a composite rating which was the sum of the numerical values of position for each of the five parameters used (e.g., a value of one was given for the lake with the greatest transparency, two for the lake with the next greatest transparency, and so on), so the lake with the lowest composite value was judged the most oligotrophic, and the lake with the highest composite value was judged the most eutrophic.

The Survey data base was much larger than that of the Wisconsin study, however, and involved more than 200 lakes surveyed in 1972 for the present assessment. Before the Survey is complete, another 500 lakes will be included for a total data base of 700+ lakes in which nine usable water quality parameters were measured. This data base includes the range of trophic conditions from some of the most pristine lakes and reservoirs in the United States to some of the most eutrophic and, therefore, will provide an excellent "relative" classification system which could be used to determine the trophic condition of any lake not in the original sample of 700 lakes (~200 treated in this report).

Rather than the positional ranking used by Lüeschow, et al., a percentile ranking procedure was used. In this procedure, for each of the unweighted parameters used, the percentage of the 200+ lakes exceeding Lake X in that parameter, e.g. level of chlorophyll a, was determined. The final ranking value or index number is simply the sum of the percentile ranks for each of the parameters used (the values for Secchi disc transparency and minimum dissolved oxygen are subtracted from fixed values so that all parameters contribute in a positive way to the ranking).

To test the merits of what might at least be a theoretical objection to the use of correlated parameters, such as chlorophyll a and phosphorus or chlorophyll a and Secchi disc transparency, percentile rankings were determined with various combinations of the nine most pertinent parameters

(a tabulation of seven non-weighted parameter combinations and resulting rankings by the percentile method and two non-weighted parameter combinations and resulting rankings by multivariate analysis is appended to this report). Two of the combinations, one with six parameters and the other with seven, appear to provide the best fit (with two kinds of exceptions as noted below), and both combinations include correlated parameters*.

Fortunately, a judgment of fit could be made with a degree of confidence because a number of the 1972 lakes previously had been studied by others, and the trophic condition of these lakes was generally agreed upon. Among these "bench-mark" lakes were Lake Zoar, Connecticut; Sebasticook Lake, Maine; Houghton and Higgins lakes, Michigan; Minnetonka and Shagawa lakes, Minnesota; Lake Winnipesaukee, New Hampshire; the Finger Lakes, New York; Lake Memphremagog, Vermont; and Geneva, Green, Kegonsa, and Shawano lakes in Wisconsin.

Table 1, 2, and 3 provide an example of how the percentile ranking system is used to develop an index. Nine Maine lakes, studied in 1972, provide the data base in this example.

The six parameters (Table 1) which are used in combination to arrive at an index number (Table 3), were those which seemed to provide the best

* The six-parameter ranking included the median total phosphorus, dissolved phosphorus, and inorganic nitrogen; the mean chlorophyll a; 500 minus the mean Secchi depth; and 15 minus the minimum dissolved oxygen. The algal assay control yield was added in the seven parameter ranking. Respectively, these are combinations #1 and #2 in the appended tabulation.

TABLE 1

Values of the Six Parameters Used in Developing a Trophic Index Based Only on a Data Base of Nine Maine Lakes

| Lake Code | Lake Name | Median Total P (mg/l) | Median Inorg N (mg/l) | 500-Mean Sec (inches) | Mean Chlorophyll a (µg/l) | 15-Min DO (mg/l) | Median Diss P (mg/l) |
|---|---|---|---|---|---|---|---|
| 2304 | Estes Lake | 0.094 | 0.230 | 459 | 28.3 | 12.8 | 0.057 |
| 2306 | Long Lake | 0.008 | 0.080 | 365 | 3.2 | 9.2 | 0.006 |
| 2308 | Mattawamkeag Lake | 0.011 | 0.120 | 438 | 2.0 | 11.6 | 0.007 |
| 2309 | Moosehead Lake | 0.005 | 0.180 | 351 | 1.5 | 7.6 | 0.003 |
| 2310 | Rangeley Lake | 0.007 | 0.110 | 352 | 2.4 | 7.8 | 0.005 |
| 2311 | Sebago Lake | 0.004 | 0.155 | 301 | 1.5 | 6.4 | 0.003 |
| 2312 | Sebasticook Lake | 0.050 | 0.110 | 456 | 49.5 | 9.0 | 0.024 |
| 2313 | Long Lake | 0.010 | 0.200 | 396 | 6.9 | 9.0 | 0.006 |
| 2314 | Bay of Naples | 0.005 | 0.070 | 374 | 1.8 | 6.6 | 0.003 |

TABLE 2

Percent of Maine Lakes Exceeding Parameter Value of Each Lake and the Trophic Index Number of Each Maine Lake Using A Data Base of Nine Lakes

| Lake Code | Lake Name | Median Total P (mg/l) | Median Inorg N (mg/l) | 500-Mean Sec (inches) | Mean Chlorophyll a (µg/l) | 15-Min DO (mg/l) | Median Diss P (mg/l) | Index No. (Sum of Percentages) |
|---|---|---|---|---|---|---|---|---|
| 2304 | Estes Lake | 0 | 0 | 0 | 11 | 0 | 0 | 11 |
| 2306 | Long Lake | 44 | 77 | 55 | 33 | 22 | 33 | 264 |
| 2308 | Mattawamkeag Lake | 22 | 44 | 22 | 55 | 11 | 22 | 176 |
| 2309 | Moosehead Lake | 77 | 22 | 77 | 88 | 66 | 66 | 396 |
| 2310 | Rangeley Lake | 55 | 55 | 66 | 44 | 55 | 55 | 330 |
| 2311 | Sebago Lake | 88 | 33 | 88 | 77 | 88 | 77 | 451 |
| 2312 | Sebasticook Lake | 11 | 55 | 11 | 0 | 33 | 11 | 121 |
| 2313 | Long Lake | 33 | 11 | 33 | 22 | 33 | 33 | 165 |
| 2314 | Bay of Naples | 66 | 88 | 44 | 66 | 77 | 77 | 418 |

TABLE 3

Trophic Index Number and Trophic Condition of Each Surveyed Maine Lake Using Data Base of Nine Lakes

| Rank | Lake Code | Lake Name | Index No. | Trophic Condition |
|---|---|---|---|---|
| 1 | 2311 | Sebago Lake | 451 | O |
| 2 | 2314 | Bay of Naples | 418 | O |
| 3 | 2309 | Moosehead Lake | 396 | O |
| 4 | 2310 | Rangeley Lake | 330 | O |
| 5 | 2306 | Long Lake | 264 | M |
| 6 | 2308 | Mattawamkeag Lake | 176 | M |
| 7 | 2313 | Long Lake | 165 | M |
| 8 | 2312 | Sebasticook Lake | 121 | E |
| 9 | 2304 | Estes Lake | 11 | HE |

O - oligotrophic
M - mesotrophic
E - eutrophic
HE - hypereutrophic

separation of trophic condition when applied to the entire group of 209 lakes.

Table 1 simply depicts the values of each parameter for the nine-Maine lakes. Table 2 represents, for each parameter, the percent of lakes in the data base (9 lakes) which exceed the parameter level for the lake of interest. The last column in the table is the trophic index number which is the sum of the percentiles for each parameter.

Using the data base of only 9 lakes, the highest percentile which can be achieved for any parameter is 88 (8/9); therefore the highest possible index number is 528 (6x88). In Table 3 the nine Maine lakes are arrayed in order of their trophic index number from most oligotrophic to the most eutrophic lake and also classified according to the traditional system of oligo-, meso-, eutrophic, or hypereutrophic.

The example of the nine Maine lakes does not include either of the two kinds of exceptions to the good fit of rankings referred to on page 3. The two exceptions are (1) water bodies with very short hydraulic retention times (less than five days) and (2) water bodies characterized by extensive littoral zones, and excessive productio[illegible]f macrophytes. In the first case, the essentially "flow-through" hydraulic regimes result in flushing of nutrients, and nutrient concentrations may remain relatively low in spite of loading rates that frequently are very high. In the second case, the macrophytes may compete effectively with algae for the available nutrients with the result that nutrient levels frequently are

low, chlorophyll levels are low (because algal populations are low), and Secchi disc values may be relatively high (possibly a combination of fewer algae and the enhancement of sedimentation of particulate matter in the relatively quiet waters provided by the weed beds).

While the mean hydraulic retention time can be quantified and used as a parameter in ranking if it is known, the volumes of many of the 1972 Survey study waters are not known, and the retention times cannot be determined. Likewise, if macrophyte populations could be conveniently quantified, this parameter could also be used in ranking the waters.

The same procedures explained above for the nine Maine lakes were applied to all of the lakes surveyed in 1972 representing a data base of 209 water bodies of many different trophic conditions. With this data set, the highest index number which could be achieved would be 594 (99 x 6) which would represent the most oligotrophic lake and the lowest index number which could be achieved would be 0, representing the most eutrophic lake.

Table 4 lists the 209 lakes ranked in order from best to worst trophic condition according to the index numbers and also indicates the trophic state nomenclature (oligotrophic, mesotrophic, or eutrophic) which is believed to typify each water body.

In general, the conclusion can be drawn from Table 4 that those lakes with a trophic index number of 500-600 correspond to a very good trophic condition and are oligotrophic with the transitional range to mesotrophic beginning in the 500-525 range.

TABLE 4

Trophic State, Trophic Index Number, and Rank
in Order of Decreasing Trophic Condition for
National Eutrophication Survey Lakes Sampled in 1972

| RANK | LAKE CODE | LAKE NAME | INDEX NO. | TROPHIC CONDITION |
|---|---|---|---|---|
| 1 | 2314 | Bay of Naples | 573 | O |
| 2 | 2311 | Sebago Lake | 566 | O |
| 3 | 3303 | Lake Winnipesaukee | 562 | O |
| 4 | 5571 | Crystal Lake | 549 | O |
| 5 | 2695 | Higgins Lake | 547 | O |
| 6 | 2309 | Moosehead Lake | 547 | O |
| 7 | 2310 | Rangeley Lake | 546 | O |
| 8 | 3634 | Schroon Lake | 541 | O |
| 9 | 26A2 | Boardman Hydro Pond | 524 | M |
| 10 | 2306 | Long Lake | 517 | M |
| 11 | 5572 | Trout Lake | 507 | M |
| 12 | 2617 | Lake Charlevoix | 502 | O |
| 13 | 3604 | Canandaigua Lake | 497 | O-M |
| 14 | 3619 | Long Lake | 496 | M |
| 15 | 3617 | Keuka Lake | 493 | M |
| 16 | 2704* | Badger Lake | 487 | M-E |
| 17 | 3629 | Raquette Pond | 486 | M |
| 18 | 3635 | Seneca Lake | 482 | M |
| 19 | 3606 | Carry Falls Reservoir | 471 | M |
| 20 | 27B0 | White Bear Lake | 464 | M |
| 21 | 2313 | Long Lake | 463 | M |
| 22 | 5011 | Waterbury Reservoir | 460 | M |
| 23 | 2694 | Crystal Lake | 459 | M |
| 24 | 2771 | Rabbit Lake | 457 | M |
| 25 | 5002** | Clyde Pond | 455 | E |
| 26 | 5561 | Lake Geneva | 453 | M |
| 27 | 5005 | Harriman Reservoir | 452 | M |
| 28 | 5564 | Rock Lake | 451 | M |

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| RANK | LAKE CODE | LAKE NAME | INDEX NO. | TROPHIC CONDITION |
|---|---|---|---|---|
| 29 | 27B2 | Green Lake | 451 | M |
| 30 | 2308 | Mattawamkeag Lake | 449 | M |
| 31 | 3632 | Sacandaga Reservoir | 444 | M |
| 32 | 2696 | Houghton Lake | 443 | M |
| 33 | 27B9 | Lake Carlos | 441 | M |
| 34 | 5008 | Lake Memphremagog | 438 | E |
| 35 | 5007** | Lamoille Lake | 433 | E |
| 36 | 3627 | Owasco Lake | 431 | M-E |
| 37 | 2788 | Swan Lake | 431 | M |
| 38 | 3608* | Lake Cayuga | 426 | M |
| 39 | 5560* | Browns Lake | 425 | E |
| 40 | 5010** | Lake Arrowhead | 425 | E |
| 41 | 2730 | Fall Lake | 425 | M |
| 42 | 2746 | Leech Lake | 422 | M |
| 43 | 5563* | Lac La Belle | 419 | E |
| 44 | 2610** | Betsie Lake | 419 | E |
| 45 | 5539* | Shawano Lake | 418 | E |
| 46 | 3639* | Conesus Lake | 418 | E |
| 47 | 2710 | Birch Lake | 416 | E |
| 48 | 5536* | Pine Lake | 412 | E |
| 49 | 5532* | Oconomowoc Lake | 403 | E |
| 50 | 5519 | Green Lake | 403 | M |
| 51 | 3636 | Swan Lake | 403 | E |
| 52 | 5569* | Middle Lake | 397 | M-E |
| 53 | 3306* | Kelly Falls Pond | 393 | E |
| 54 | 3610 | Chautauqua Lake | 391 | E |
| 55 | 3615 | Huntington Lake | 390 | E |
| 56 | 2672** | Rogers Pond | 387 | E |

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| RANK | LAKE CODE | LAKE NAME | INDEX NO. | TROPHIC CONDITION |
|---|---|---|---|---|
| 57 | 5001 | Champlain Lake | 385 | M |
| 58 | 3302** | Powder Mill Pond | 383 | E |
| 59 | 27B4 | Darling Lake | 380 | E |
| 60 | 3633 | Saratoga Lake | 373 | E |
| 61 | 5558* | Okauchee Lake | 372 | E |
| 62 | 2761 | Minnewaska Lake | 372 | E |
| 63 | 2674** | Sanford Lake | 371 | E |
| 64 | 5566 | Round Lake | 370 | E |
| 65 | 3602 | Black Lake | 368 | E |
| 66 | 2793 | Trout Lake | 367 | E |
| 67 | 2649** | Manistee Lake | 365 | E |
| 68 | 2715 | Cass Lake | 364 | M |
| 69 | 27A9* | Forest Lake | 360 | E |
| 70 | 2737 | Gull Lake | 358 | E |
| 71 | 27B5 | Le Homme Dieu | 357 | E |
| 72 | 3640 | Lower St. Regis | 354 | E |
| 73 | 2745 | Lake of the Woods | 353 | E |
| 74 | 3625 | Otter Lake | 352 | E |
| 75 | 3613 | Goodyear Lake | 351 | E |
| 76 | 2751 | Menomin Lake | 346 | E |
| 77 | 5574 | Willow Reservoir | 345 | E |
| 78 | 27C1 | Lake Bemidji | 344 | E |
| 79 | 2711 | Blackduck Lake | 342 | E |
| 80 | 4402** | Slatersville Reservoir | 340 | E |
| 81 | 2698 | Pere Marquette Lake | 336 | E |
| 82 | 2688 | White Lake | 334 | E |
| 83 | 2618 | Lake Chemung | 334 | E |
| 84 | 0902 | Bantam Lake | 332 | # |

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| RANK | LAKE CODE | LAKE NAME | INDEX NO. | TROPHIC CONDITION |
|---|---|---|---|---|
| 85 | 3641 | Allegheny Reservoir | 330 | E |
| 86 | 2765 | Pelican Lake | 330 | E |
| 87 | 2673 | Ross Reservoir | 330 | E |
| 88 | 3607 | Cassadaga Lake | 328 | E |
| 89 | 27C0 | Andrusia Lake | 328 | E |
| 90 | 5557 | Pewaukee Lake | 327 | E |
| 91 | 3305 | Glenn Lake | 327 | E |
| 92 | 0912 | Shelton Lake | 325 | E |
| 93 | 5556 | Lake Wissota | 324 | E |
| 94 | 5575 | Elk Lake | 303 | E |
| 95 | 2509 | Rochdale Pond | 303 | E |
| 96 | 2716 | Clearwater Lake | 300 | E |
| 97 | 2780 | Shagawa Lake | 297 | E |
| 98 | 27B3 | Nest Lake | 293 | E |
| 99 | 2312 | Sebasticook Lake | 293 | E |
| 100 | 5573 | Long Lake | 292 | E |
| 101 | 5550 | Wapogasset Lake | 291 | E |
| 102 | 5576 | Yellow Lake | 286 | E |
| 103 | 2712 | Blackhoof Lake | 279 | E |
| 104 | 2685 | Union Lake | 279 | E |
| 105 | 2621 | Constantine Reservoir | 273 | E |
| 106 | 26A0 | Holloway Reservoir | 271 | E |
| 107 | 0904 | Eagleville Lake | 271 | E |
| 108 | 5551 | Lake Wausau | 266 | E |
| 109 | 3630 | Round Lake | 266 | E |
| 110 | 2697 | Thompson Lake | 266 | E |
| 111 | 5562 | Lake Como | 265 | E |
| 112 | 27A7 | St Croix Lake | 264 | E |

TABLE 4
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| RANK | LAKE CODE | LAKE NAME | INDEX NO. | TROPHIC CONDITION |
|---|---|---|---|---|
| 113 | 5578 | St Croix Lake | 262 | E |
| 114 | 2720 | Cranberry Lake | 262 | E |
| 115 | 2665 | Pentwater Lake | 259 | E |
| 116 | 27A2 | Wolf Lake | 258 | E |
| 117 | 0911 | Lillinoah Lake | 258 | E |
| 118 | 2749 | Whitewater Lake | 257 | E |
| 119 | 5509 | Butternut Lake | 256 | E |
| 120 | 5508 | Butte Des Morts | 254 | E |
| 121 | 2683 | Thornapple Lake | 254 | E |
| 122 | 5535 | Pigeon Lake | 247 | E |
| 123 | 0910 | Zoar Lake | 246 | E |
| 124 | 27A1 | Winona Lake | 245 | E |
| 125 | 2725 | Elbow Lake | 244 | E |
| 126 | 2699 | Strawberry Lake | 243 | E |
| 127 | 2760 | Lake Minnetonka | 241 | E |
| 128 | 2643 | Kent Lake | 237 | E |
| 129 | 2659 | Muskegon Lake | 231 | E |
| 130 | 2692 | Long Lake | 230 | E |
| 131 | 5538 | Poygan Lake | 229 | E |
| 132 | 2786 | Superior Bay | 229 | E |
| 133 | 2513 | Hudson Impoundment | 225 | E |
| 134 | 2756 | Mashkenode Lake | 223 | E |
| 135 | 5548 | Town Line Lake | 218 | E |
| 136 | 5546 | Tainter Lake | 216 | E |
| 137 | 27B6 | Calhoun Lake | 216 | E |
| 138 | 5520 | Kegonsa Lake | 214 | E |
| 139 | 3637 | Swinging Bridge Reservoir | 214 | E |
| 140 | 2709 | Big Stone Lake | 213 | E |

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| RANK | LAKE CODE | LAKE NAME | INDEX NO. | TROPHIC CONDITION |
|---|---|---|---|---|
| 141 | 2777 | Sakatah Lake | 211 | E |
| 142 | 5581 | Superior Bay | 209 | E |
| 143 | 2693 | St. Louis Reservoir | 209 | E |
| 144 | 2705 | Bartlett Lake | 208 | E |
| 145 | 5502 | Altoona Lake | 207 | E |
| 146 | 5531 | Lake Nagawicka | 205 | E |
| 147 | 2792 | Trace Lake | 205 | E |
| 148 | 2511 | Billerica Impoundment | 204 | E |
| 149 | 2503 | Harris Pond | 203 | E |
| 150 | 2304 | Estes Lake | 201 | E |
| 151 | 2671 | Randall Lake | 199 | E |
| 152 | 2731 | Fanny Lake | 196 | E |
| 153 | 5510 | Castle Rock Flowage | 193 | E |
| 154 | 26A1 | Caro Reservoir | 193 | E |
| 155 | 5545 | Swan Lake | 191 | E |
| 156 | 2748 | Little Lake | 191 | E |
| 157 | 5503 | Beaver Dam Lake | 189 | E |
| 158 | 5534 | Petenwell Flowage | 186 | E |
| 159 | 0901 | Aspinook Lake | 186 | E |
| 160 | 27C3 | Cottonwood Lake | 182 | E |
| 161 | 2609 | Belleville Lake | 181 | E |
| 162 | 2796 | Tuttle Lake | 180 | E |
| 163 | 2613 | Brighton Lake | 180 | E |
| 164 | 0905 | Hanover Pond | 178 | E |
| 165 | 5522 | Koshkonong Lake | 176 | E |
| 166 | 2752 | Malmedal Lake | 176 | E |
| 167 | 5555 | Wisconsin Lake | 174 | E |
| 168 | 2719 | Cokato Lake | 171 | E |

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| RANK | LAKE CODE | LAKE NAME | INDEX NO. | TROPHIC CONDITION |
|---|---|---|---|---|
| 169 | 5554 | Lake Winnebago | 170 | E |
| 170 | 2776 | St. Louis Bay | 168 | E |
| 171 | 3611 | Cross Lake | 167 | E |
| 172 | 5513 | Lake Delavan | 165 | E |
| 173 | 2753 | Mud Lake at Maple Lake | 162 | E |
| 174 | 2507 | Woods Pond | 162 | E |
| 175 | 2750 | Madison Lake | 161 | E |
| 176 | 2504 | Maynard Impoundment | 160 | E |
| 177 | 2706 | Bear Lake | 159 | E |
| 178 | 5565 | Big Eau Pleine Reservoir | 158 | E |
| 179 | 2629 | Ford Lake | 155 | E |
| 180 | 2606 | Barton Lake | 150 | E |
| 181 | 27A4 | Lake Pepin | 146 | E |
| 182 | 5582 | Lake Pepin | 144 | E |
| 183 | 5515 | Eau Claire Lake | 141 | E |
| 184 | 27A6 | Spring Lake | 139 | E |
| 185 | 2603 | Allegan Lake | 138 | E |
| 186 | 2508 | Mattfield Impoundment | 137 | E |
| 187 | 27B8 | Lost Lake | 134 | E |
| 188 | 2640 | Jordan Lake | 133 | E |
| 189 | 5570 | Grand Lake | 132 | E |
| 190 | 27A8 | Budd Lake | 130 | E |
| 191 | 3616 | Irondequoit Bay | 128 | E |
| 192 | 27A5 | Zumbro Lake | 126 | E |
| 193 | 5580 | St. Louis Bay | 125 | E |
| 194 | 2648 | Lake Macatawa | 123 | E |
| 195 | 27B1 | Wagonga Lake | 122 | E |
| 196 | 2713 | Buffalo Lake | 118 | HE |

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| RANK | LAKE CODE | LAKE NAME | INDEX NO. | TROPHIC CONDITION |
|---|---|---|---|---|
| 197 | 2691 | Mona Lake | 118 | HE |
| 198 | 2782 | Silver Lake | 114 | HE |
| 199 | 0903 | Community Lake | 112 | HE |
| 200 | 2702 | Albert Lea Lake | 102 | HE |
| 201 | 27C2 | Mud Lake | 100 | HE |
| 202 | 2714 | Carrigan Lake | 99 | HE |
| 203 | 2502 | Hager Pond | 94 | HE |
| 204 | 2785 | St. Clair Lake | 93 | HE |
| 205 | 4403 | Turner Reservoir | 92 | HE |
| 206 | 2631 | Fremont Lake | 92 | HE |
| 207 | 5559 | Tichigan Lake | 80 | HE |
| 208 | 27A3 | Woodcock Lake | 60 | HE |
| 209 | 27B7 | Wallmark Lake | 41 | HE |

O - Oligotrophic
M - Mesotrophic
E - Eutrophic
HE - Hypereutrophic

* - Weeds
** - Short Hydraulic Retention Time

Lakes with a trophic index of 420-499 are those which would ordinarily be classed mesotrophic and below 420 the lakes become progressively more eutrophic. The 300-419 range of the index represents lakes which are eutrophic and have occasional nuisance algal problems but still may support excellent fisheries. Below 300, nuisance conditions may be expected more frequently; however, even some of these lakes may be expected to support good fish populations.

The reader should understand that the index number ranges mentioned above, which correspond to the various trophic states, are only valid when used with the data base of 209 lakes and reservoirs considered in this report. If a different data base were used, for example, one containing a higher percentage of high quality lakes, the resulting index number might be interpreted quite differently, e.g. oligotrophic rather than eutrophic.

As discussed earlier, all lakes and reservoirs sampled in 1972 were included in this index regardless of morphometry or detention time. Therefore, lakes with relatively low trophic index numbers may have the apparent potential for developing nuisance conditions but may not do so because of extremely short flow-through times.

It is of interest to evaluate the proposed index in terms of lakes and reservoirs with known nuisance levels of algae. Such an evaluation was made with water bodies listed in "Problem Lakes of the United States"

which was compiled by Ketelle and Uttormark (1971) of the University of Wisconsin Water Resources Center. In Table 5, lakes which were cited in the aforementioned publication and were also included in the Survey are listed by State and the Trophic Index Number for each lake is also given.

The data in Table 5 substantiate that for overall lake quality, the trophic index does differentiate the high quality lakes from those which have the potential of developing nuisance conditions. If a specific lake were beginning to exhibit signs of eutrophication along shoreline areas or in bays, the index would not show the localized degradation unless the lake was specifically sampled in the worst areas. This characteristic would, however, be a weakness in any simple trophic index system.

While the major Survey effort in ranking of lakes has been with the percentile method outlined above, the more sophisticated methods of statistical analysis have also been examined. Thus far, Survey data have been subjected to the multivariate analysis recently recommended by Harkins (1974), and Don A. Pierce, Associate Professor of Statistics at Oregon State University, has employed a discriminate function analysis. Also, Dale H. P. Boland, a doctoral candidate at Oregon State University, who is investigating the feasibility of estimating the trophic status of inland lakes through the use of the Earth Resources Technology Satellite (ERTS-1) multispectral scanner and is using the ground-truth data of 100 of the 1972 Survey lakes (see Working Paper

TABLE 5

Trophic Index Numbers for Lake and Reservoirs Cited in "Problem Lakes of the United States" and Included in the National Eutrophication Survey

| State | Lake Name | Trophic Index Number |
|---|---|---|
| Connecticut | Bantam | 332 |
| | Lillinoah | 258 |
| | Zoar | 246 |
| Maine | Estes | 201 |
| | Sebasticook | 293 |
| Massachusetts | Hager Pond | 94 |
| Michigan | Barton | 150 |
| | Brighton | 180 |
| | Betsie | 419 |
| | Chemung | 334 |
| | Ford | 155 |
| | Fremont | 92 |
| | Jordan | 133 |
| | Kent | 237 |
| | Macatawa | 123 |
| | Manistee | 365 |
| | Mona | 118 |
| | Muskegon | 231 |
| | Randall | 199 |
| | White | 334 |
| Minnesota | Big Stone | 213 |
| | Budd | 130 |
| | Madison | 161 |
| | Minnetonka | 241 |
| | Shagawa | 297 |
| | Sakatah | 211 |
| New York | Cayuga | 426* |
| | Conesus | 418 |
| | Saratoga | 373 |
| | Schroon | 541* |
| | Seneca | 482* |
| Wisconsin | Butternut | 256 |
| | Butte Des Morts | 254 |
| | Delavan | 165 |
| | Koshkonong | 176 |
| | Kegonsa | 214 |
| | Nagawicka | 205 |
| | Pewaukee | 327 |
| | Poygon | 229 |
| | Shawano | 418** |
| | Tichigan | 80 |
| | Winnebago | 170 |
| Vermont | Champlain | 385 |
| | Memphremagog | 439† |

* Generally high quality lakes showing positive signs of deterioration.
** A naturally eutrophic lake with an aquatic macrophyte problem.
† An oligotrophic lake which has deteriorated in the south end due to phosphorus inputs from U.S. point sources.

No. 10), has subjected the data to principal component analysis and cluster analysis. None of the complex analyses noted above provide a better ranking of the lakes than the percentile method (some are not as good), and all have the same failing as the percentile method with respect to retention times and macrophytes.

TROPHIC INDEX USE

Using the data base of 209 lakes as presented or a larger base as the data are produced by the Survey, it would be relatively easy to determine the relative trophic condition of an unknown lake (Lake X) by determining its trophic index number. Changes in the trophic condition of Lake X could also be followed in the same manner by determining its trophic index number each year and charting the improvements, deterioration, or status quo, whichever the case might be.

The data required to compute the trophic index would have to be for the same parameters used in the index system presented above; i.e., (1) total phosphorus, (2) dissolved phosphorus, (3) inorganic nitrogen, (4) Secchi depth, (5) minimum dissolved oxygen (in the hypolimnion if stratification occurs), and (6) chlorophyll a. Each of the values used should be means or medians for the entire lake or at least values which are believed to be representative of the entire water body or that portion which the investigator is interested in classifying.

After the data for the appropriate parameters had been gathered, the percentile table (Table 6) would be used to determine for each parameter the percent of lakes exceeding the value for the lake of interest. The

TABLE 6

Parameter Value Percentiles for Establishing Trophic Index Numbers for Unclassified Lakes; Based on 209 Lakes Sampled by the National Eutrophication Survey in 1972

| Median Total P (mg/l) | Percent Higher | Median Inorg N (mg/l) | Percent Higher | 500-Mean Secchi (inches) | Percent Higher | Mean Chlorophyll a (µg/l) | Percent Higher | 15-Minimum DO (mg/l) | Percent Higher | Median Dissolved P (mg/l) | Percent Higher |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.004 | 99 | 0.060 | 99 | 184.000 | 99 | 1.043 | 99 | 4.800 | 99 | 0.003 | 99 |
| 0.004 | 99 | 0.060 | 99 | 268.500 | 99 | 1.267 | 99 | 5.300 | 99 | 0.003 | 99 |
| 0.005 | 98 | 0.070 | 97 | 272.555 | 98 | 1.462 | 98 | 6.200 | 98 | 0.003 | 98 |
| 0.005 | 98 | 0.070 | 97 | 283.667 | 98 | 1.487 | 98 | 6.300 | 98 | 0.003 | 98 |
| 0.006 | 97 | 0.070 | 97 | 300.933 | 97 | 1.500 | 97 | 6.400 | 97 | 0.004 | 95 |
| 0.006 | 97 | 0.070 | 97 | 323.250 | 97 | 1.767 | 97 | 6.600 | 95 | 0.004 | 95 |
| 0.006 | 96 | 0.080 | 95 | 338.000 | 96 | 1.767 | 96 | 6.600 | 95 | 0.004 | 95 |
| 0.007 | 95 | 0.080 | 95 | 342.875 | 96 | 1.850 | 96 | 6.600 | 95 | 0.004 | 95 |
| 0.007 | 95 | 0.080 | 95 | 351.048 | 95 | 1.989 | 95 | 6.600 | 95 | 0.004 | 95 |
| 0.007 | 95 | 0.090 | 93 | 351.250 | 95 | 2.067 | 95 | 7.000 | 94 | 0.005 | 92 |
| 0.008 | 93 | 0.090 | 93 | 351.714 | 94 | 2.075 | 94 | 7.000 | 94 | 0.005 | 92 |
| 0.008 | 93 | 0.090 | 93 | 353.000 | 94 | 2.083 | 94 | 7.000 | 94 | 0.005 | 92 |
| 0.008 | 93 | 0.090 | 93 | 354.000 | 93 | 2.233 | 93 | 7.200 | 93 | 0.005 | 92 |
| 0.008 | 93 | 0.090 | 93 | 358.667 | 93 | 2.283 | 93 | 7.200 | 93 | 0.005 | 92 |
| 0.009 | 90 | 0.100 | 91 | 359.333 | 92 | 2.433 | 92 | 7.400 | 90 | 0.005 | 92 |
| 0.009 | 90 | 0.100 | 91 | 360.778 | 92 | 2.683 | 92 | 7.400 | 90 | 0.005 | 92 |
| 0.009 | 90 | 0.100 | 91 | 362.000 | 91 | 2.986 | 31 | 7.400 | 90 | 0.005 | 91 |
| 0.009 | 90 | 0.100 | 91 | 363.500 | 91 | 3.008 | 91 | 7.400 | 90 | 0.006 | 88 |
| 0.009 | 90 | 0.110 | 89 | 364.111 | 90 | 3.067 | 90 | 7.400 | 90 | 0.006 | 88 |
| 0.009 | 90 | 0.110 | 89 | 365.333 | 90 | 3.067 | 90 | 7.440 | 90 | 0.006 | 88 |
| 0.010 | 88 | 0.110 | 89 | 366.333 | 89 | 3.189 | 89 | 7.500 | 89 | 0.006 | 88 |
| 0.010 | 88 | 0.120 | 88 | 373.875 | 89 | 3.236 | 89 | 7.500 | 89 | 0.006 | 88 |
| 0.010 | 88 | 0.120 | 88 | 374.000 | 88 | 3.467 | 88 | 7.600 | 88 | 0.006 | 88 |
| 0.010 | 88 | 0.120 | 88 | 374.500 | 6d | 3.533 | 88 | 7.600 | 88 | 0.006 | 88 |
| 0.011 | 88 | 0.125 | 88 | 380.000 | 88 | 3.540 | 88 | 7.600 | 88 | 0.006 | 88 |
| 0.011 | 87 | 0.130 | 86 | 383.833 | 87 | 3.783 | 87 | 7.700 | 87 | 0.007 | 85 |
| 0.011 | 87 | 0.130 | 86 | 385.333 | 87 | 3.810 | 87 | 7.700 | 87 | 0.007 | 85 |
| 0.012 | 86 | 0.130 | 86 | 385.364 | 86 | 4.333 | 86 | 7.800 | 84 | 0.007 | 85 |

TABLE 6
(Page 2)

| Median Total P (mg/l) | Percent Higher | Median Inorg N (mg/l) | Percent Higher | 500-Mean Secchi (inches) | Percent Higher | Mean Chlorophyll a (µg/l) | Percent Higher | 15-Minimum DO (mg/l) | Percent Higher | Median Dissolved P (mg/l) | Percent Higher |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.013 | 84 | 0.135 | 85 | 388.250 | 86 | 4.567 | 86 | 7.800 | 84 | 0.007 | 85 |
| 0.013 | 84 | 0.135 | 85 | 388.364 | 85 | 4.633 | 85 | 7.800 | 84 | 0.007 | 85 |
| 0.013 | 84 | 0.135 | 85 | 389.000 | 85 | 4.667 | 85 | 7.800 | 84 | 0.007 | 84 |
| 0.013 | 84 | 0.140 | 82 | 389.555 | 84 | 4.733 | 84 | 7.800 | 84 | 0.007 | 84 |
| 0.014 | 84 | 0.140 | 82 | 390.167 | 84 | 4.811 | 84 | 7.800 | 84 | 0.008 | 80 |
| 0.014 | 83 | 0.140 | 82 | 393.333 | 83 | 4.850 | 83 | 7.880 | 83 | 0.008 | 80 |
| 0.015 | 81 | 0.140 | 82 | 393.600 | 83 | 4.867 | 83 | 7.900 | 82 | 0.008 | 80 |
| 0.015 | 81 | 0.140 | 82 | 396.125 | 82 | 5.000 | 82 | 7.900 | 82 | 0.008 | 80 |
| 0.015 | 81 | 0.140 | 82 | 398.667 | 82 | 5.000 | 82 | 7.900 | 82 | 0.008 | 80 |
| 0.015 | 81 | 0.140 | 81 | 399.333 | 81 | 5.017 | 81 | 8.000 | 80 | 0.008 | 80 |
| 0.015 | 81 | 0.145 | 79 | 400.833 | 81 | 5.133 | 81 | 8.000 | 80 | 0.008 | 80 |
| 0.016 | 80 | 0.145 | 79 | 403.833 | 80 | 5.178 | 80 | 8.000 | 80 | 0.008 | 80 |
| 0.016 | 80 | 0.145 | 79 | 404.333 | 80 | 5.240 | 80 | 8.020 | 79 | 0.009 | 77 |
| 0.017 | 79 | 0.145 | 79 | 405.833 | 79 | 5.583 | 79 | 8.020 | 79 | 0.009 | 77 |
| 0.017 | 79 | 0.145 | 79 | 407.889 | 79 | 5.650 | 79 | 8.100 | 79 | 0.009 | 77 |
| 0.018 | 77 | 0.150 | 78 | 408.463 | 78 | 5.767 | 78 | 8.200 | 77 | 0.009 | 77 |
| 0.018 | 77 | 0.150 | 78 | 408.667 | 78 | 6.067 | 78 | 8.200 | 77 | 0.009 | 77 |
| 0.018 | 77 | 0.150 | 77 | 408.778 | 77 | 6.180 | 77 | 8.200 | 77 | 0.009 | 77 |
| 0.019 | 77 | 0.150 | 77 | 408.889 | 77 | 6.187 | 77 | 8.200 | 77 | 0.009 | 77 |
| 0.019 | 77 | 0.150 | 77 | 411.167 | 77 | 6.200 | 77 | 8.200 | 77 | 0.009 | 77 |
| 0.020 | 75 | 0.155 | 76 | 413.000 | 76 | 6.242 | 76 | 8.300 | 76 | 0.009 | 76 |
| 0.020 | 75 | 0.155 | 76 | 413.454 | 76 | 6.317 | 76 | 8.400 | 74 | 0.010 | 73 |
| 0.020 | 75 | 0.160 | 75 | 415.167 | 75 | 6.400 | 75 | 8.400 | 74 | 0.010 | 73 |
| 0.020 | 75 | 0.160 | 74 | 415.333 | 75 | 6.400 | 75 | 8.400 | 74 | 0.010 | 73 |
| 0.021 | 73 | 0.160 | 74 | 416.000 | 74 | 6.700 | 74 | 8.400 | 74 | 0.010 | 73 |
| 0.021 | 73 | 0.170 | 73 | 417.778 | 74 | 6.911 | 74 | 8.420 | 74 | 0.010 | 73 |
| 0.021 | 73 | 0.170 | 73 | 418.400 | 73 | 7.011 | 73 | 8.600 | 72 | 0.010 | 73 |
| 0.022 | 72 | 0.170 | 73 | 419.500 | 73 | 7.033 | 73 | 8.600 | 72 | 0.010 | 73 |

TABLE 6
(Page 3)

| Median Total P (mg/l) | Percent Higher | Median Inorg N (mg/l) | Percent Higher | 500-Mean Secchi (inches) | Percent Higher | Mean Chlorophyll a (µg/l) | Percent Higher | 15-Minimum DO (mg/l) | Percent Higher | Median Dissolved P (mg/l) | Percent Higher |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.022 | 72 | 0.175 | 72 | 419.667 | 72 | 7.044 | 72 | 8.600 | 72 | 0.011 | 70 |
| 0.022 | 72 | 0.175 | 72 | 419.800 | 72 | 7.050 | 72 | 8.660 | 72 | 0.011 | 70 |
| 0.024 | 71 | 0.175 | 71 | 420.500 | 71 | 7.133 | 71 | 8.700 | 71 | 0.011 | 70 |
| 0.024 | 71 | 0.175 | 71 | 420.667 | 71 | 7.186 | 71 | 8.760 | 71 | 0.011 | 70 |
| 0.025 | 70 | 0.180 | 70 | 420.833 | 70 | 7.233 | 70 | 8.800 | 70 | 0.011 | 70 |
| 0.025 | 69 | 0.180 | 70 | 421.444 | 70 | 7.450 | 70 | 8.900 | 69 | 0.011 | 70 |
| 0.025 | 69 | 0.185 | 69 | 422.000 | 69 | 7.500 | 69 | 8.900 | 69 | 0.012 | 68 |
| 0.026 | 68 | 0.190 | 67 | 422.667 | 69 | 7.500 | 69 | 8.900 | 69 | 0.012 | 68 |
| 0.026 | 68 | 0.190 | 67 | 423.500 | 68 | 7.622 | 68 | 9.000 | 65 | 0.012 | 68 |
| 0.026 | 68 | 0.190 | 67 | 424.000 | 68 | 7.933 | 68 | 9.000 | 65 | 0.013 | 66 |
| 0.026 | 67 | 0.190 | 67 | 424.500 | 67 | 8.100 | 67 | 9.000 | 65 | 0.013 | 66 |
| 0.026 | 67 | 0.195 | 67 | 424.800 | 67 | 8.133 | 67 | 9.000 | 65 | 0.013 | 66 |
| 0.027 | 66 | 0.200 | 66 | 425.000 | 66 | 8.133 | 66 | 9.000 | 65 | 0.013 | 66 |
| 0.027 | 66 | 0.200 | 66 | 425.667 | 66 | 8.183 | 66 | 9.000 | 65 | 0.013 | 66 |
| 0.028 | 64 | 0.200 | 66 | 425.889 | 66 | 8.350 | 66 | 9.000 | 65 | 0.014 | 63 |
| 0.028 | 64 | 0.200 | 65 | 426.000 | 65 | 8.483 | 65 | 9.000 | 65 | 0.014 | 63 |
| 0.028 | 64 | 0.205 | 65 | 426.333 | 65 | 8.533 | 65 | 9.020 | 65 | 0.014 | 63 |
| 0.028 | 64 | 0.210 | 63 | 426.833 | 64 | 8.689 | 64 | 9.200 | 62 | 0.014 | 63 |
| 0.028 | 63 | 0.210 | 63 | 427.667 | 63 | 9.167 | 64 | 9.200 | 62 | 0.014 | 63 |
| 0.028 | 63 | 0.210 | 63 | 427.667 | 63 | 9.211 | 63 | 9.200 | 62 | 0.014 | 63 |
| 0.029 | 63 | 0.210 | 63 | 428.400 | 63 | 9.217 | 63 | 9.200 | 62 | 0.015 | 61 |
| 0.030 | 62 | 0.220 | 62 | 429.000 | 62 | 9.467 | 62 | 9.200 | 62 | 0.015 | 61 |
| 0.031 | 62 | 0.220 | 62 | 430.333 | 62 | 9.483 | 62 | 9.200 | 62 | 0.015 | 61 |
| 0.032 | 60 | 0.230 | 61 | 430.667 | 61 | 9.511 | 61 | 9.240 | 61 | 0.015 | 61 |
| 0.032 | 60 | 0.230 | 61 | 430.750 | 61 | 9.633 | 61 | 9.240 | 61 | 0.016 | 60 |
| 0.032 | 60 | 0.230 | 60 | 430.800 | 60 | 9.700 | 60 | 9.400 | 60 | 0.016 | 60 |
| 0.033 | 60 | 0.230 | 60 | 432.167 | 60 | 9.783 | 60 | 9.500 | 60 | 0.016 | 60 |
| 0.034 | 59 | 0.240 | 59 | 432.333 | 59 | 9.800 | 59 | 9.520 | 59 | 0.017 | 58 |

TABLE 6
(Page 4)

| Median Total P (mg/l) | Percent Higher | Median Inorg N (mg/l) | Percent Higher | 500-Mean Secchi (inches) | Percent Higher | Mean Chlorophyll a (µg/l) | Percent Higher | 15-Minimum DO (mg/l) | Percent Higher | Median Dissolved P (mg/l) | Percent Higher |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.034 | 59 | 0.240 | 59 | 432.333 | 59 | 9.867 | 59 | 9.600 | 58 | 0.017 | 58 |
| 0.035 | 58 | 0.240 | 57 | 432.667 | 58 | 10.067 | 58 | 9.600 | 58 | 0.017 | 58 |
| 0.035 | 58 | 0.240 | 57 | 432.750 | 58 | 10.244 | 57 | 9.600 | 58 | 0.018 | 57 |
| 0.036 | 57 | 0.240 | 57 | 432.889 | 57 | 10.244 | 57 | 9.760 | 57 | 0.018 | 57 |
| 0.038 | 57 | 0.240 | 57 | 434.500 | 57 | 10.250 | 57 | 9.800 | 57 | 0.018 | 57 |
| 0.039 | 56 | 0.250 | 56 | 434.667 | 56 | 10.383 | 56 | 10.000 | 55 | 0.018 | 56 |
| 0.039 | 56 | 0.255 | 56 | 435.500 | 55 | 10.517 | 56 | 10.000 | 55 | 0.019 | 56 |
| 0.040 | 55 | 0.260 | 55 | 435.500 | 55 | 10.667 | 55 | 10.000 | 55 | 0.019 | 55 |
| 0.041 | 55 | 0.260 | 55 | 436.444 | 55 | 10.678 | 55 | 10.100 | 55 | 0.019 | 55 |
| 0.042 | 55 | 0.260 | 55 | 437.000 | 54 | 10.800 | 55 | 10.320 | 55 | 0.020 | 54 |
| 0.043 | 53 | 0.270 | 53 | 437.000 | 54 | 11.061 | 54 | 10.360 | 54 | 0.020 | 54 |
| 0.043 | 53 | 0.270 | 53 | 437.667 | 54 | 11.117 | 54 | 10.400 | 52 | 0.020 | 53 |
| 0.043 | 53 | 0.270 | 53 | 437.833 | 53 | 11.133 | 53 | 10.400 | 52 | 0.020 | 53 |
| 0.043 | 53 | 0.270 | 53 | 438.000 | 52 | 11.133 | 53 | 10.400 | 52 | 0.020 | 53 |
| 0.043 | 51 | 0.270 | 52 | 438.000 | 52 | 11.317 | 52 | 10.400 | 52 | 0.021 | 52 |
| 0.043 | 51 | 0.280 | 51 | 438.300 | 52 | 11.400 | 52 | 10.400 | 52 | 0.022 | 51 |
| 0.043 | 51 | 0.280 | 51 | 439.375 | 51 | 11.433 | 51 | 10.460 | 51 | 0.022 | 51 |
| 0.043 | 51 | 0.287 | 51 | 441.000 | 51 | 11.500 | 51 | 10.500 | 51 | 0.022 | 50 |
| 0.044 | 50 | 0.290 | 50 | 441.333 | 50 | 11.833 | 49 | 10.600 | 50 | 0.022 | 50 |
| 0.044 | 50 | 0.290 | 50 | 441.500 | 50 | 11.833 | 49 | 10.600 | 50 | 0.023 | 49 |
| 0.045 | 49 | 0.300 | 49 | 441.667 | 49 | 11.833 | 49 | 10.700 | 49 | 0.023 | 49 |
| 0.047 | 48 | 0.300 | 48 | 442.833 | 49 | 11.878 | 49 | 10.800 | 47 | 0.023 | 49 |
| 0.047 | 48 | 0.300 | 48 | 445.444 | 48 | 11.967 | 48 | 10.800 | 47 | 0.024 | 48 |
| 0.048 | 48 | 0.305 | 48 | 445.833 | 48 | 11.967 | 48 | 10.800 | 47 | 0.024 | 48 |
| 0.048 | 47 | 0.305 | 47 | 446.000 | 47 | 12.033 | 47 | 10.800 | 47 | 0.025 | 47 |
| 0.049 | 47 | 0.305 | 47 | 446.500 | 47 | 12.233 | 47 | 10.800 | 47 | 0.025 | 47 |
| 0.049 | 46 | 0.310 | 46 | 446.667 | 46 | 12.444 | 46 | 10.880 | 46 | 0.026 | 46 |
| 0.050 | 45 | 0.310 | 46 | 446.667 | 46 | 12.467 | 46 | 10.960 | 46 | 0.026 | 46 |

TABLE 6
(Page 5)

| Median Total P (mg/l) | Percent Higher | Median Inorg N (mg/l) | Percent Higher | 500-Mean Secchi (inches) | Percent Higher | Mean Chlorophyll a (µg/l) | Percent Higher | 15-Minimum DO (mg/l) | Percent Higher | Median Dissolved P (mg/l) | Percent Higher |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.050 | 45 | 0.320 | 45 | 447.000 | 45 | 12.467 | 45 | 11.000 | 44 | 0.026 | 45 |
| 0.050 | 45 | 0.320 | 45 | 447.600 | 45 | 12.600 | 45 | 11.000 | 44 | 0.026 | 45 |
| 0.052 | 44 | 0.330 | 44 | 448.667 | 44 | 12.750 | 44 | 11.000 | 44 | 0.027 | 44 |
| 0.054 | 44 | 0.335 | 44 | 448.667 | 44 | 12.950 | 44 | 11.300 | 44 | 0.027 | 44 |
| 0.055 | 44 | 0.335 | 44 | 448.667 | 44 | 12.967 | 44 | 11.300 | 44 | 0.028 | 43 |
| 0.057 | 43 | 0.340 | 43 | 450.444 | 43 | 13.050 | 43 | 11.380 | 43 | 0.028 | 43 |
| 0.057 | 43 | 0.340 | 43 | 450.667 | 43 | 13.267 | 43 | 11.400 | 42 | 0.028 | 42 |
| 0.057 | 42 | 0.350 | 42 | 451.333 | 42 | 13.333 | 42 | 11.400 | 42 | 0.028 | 42 |
| 0.058 | 42 | 0.355 | 41 | 451.667 | 42 | 13.383 | 42 | 11.420 | 42 | 0.029 | 41 |
| 0.059 | 41 | 0.355 | 41 | 452.857 | 41 | 13.483 | 41 | 11.520 | 41 | 0.029 | 41 |
| 0.059 | 41 | 0.355 | 41 | 453.000 | 41 | 13.667 | 41 | 11.600 | 40 | 0.029 | 41 |
| 0.060 | 40 | 0.360 | 40 | 453.667 | 40 | 13.683 | 40 | 11.600 | 40 | 0.030 | 40 |
| 0.061 | 40 | 0.360 | 40 | 454.000 | 40 | 13.789 | 40 | 11.900 | 40 | 0.030 | 40 |
| 0.062 | 39 | 0.380 | 38 | 455.000 | 39 | 13.791 | 39 | 12.000 | 39 | 0.031 | 39 |
| 0.063 | 39 | 0.380 | 38 | 455.000 | 39 | 13.844 | 39 | 12.000 | 39 | 0.031 | 39 |
| 0.064 | 38 | 0.380 | 38 | 455.500 | 38 | 14.000 | 38 | 12.200 | 38 | 0.032 | 38 |
| 0.065 | 37 | 0.385 | 38 | 456.000 | 36 | 14.089 | 38 | 12.200 | 38 | 0.032 | 38 |
| 0.065 | 37 | 0.395 | 37 | 456.000 | 36 | 14.150 | 37 | 12.300 | 37 | 0.033 | 37 |
| 0.068 | 37 | 0.395 | 37 | 456.000 | 36 | 14.380 | 37 | 12.600 | 36 | 0.033 | 37 |
| 0.070 | 36 | 0.395 | 36 | 456.000 | 36 | 14.550 | 36 | 12.600 | 36 | 0.036 | 36 |
| 0.071 | 36 | 0.410 | 35 | 456.167 | 35 | 14.650 | 36 | 12.800 | 35 | 0.036 | 36 |
| 0.073 | 35 | 0.410 | 35 | 456.167 | 35 | 14.733 | 35 | 12.800 | 35 | 0.036 | 35 |
| 0.074 | 35 | 0.410 | 34 | 456.167 | 35 | 14.878 | 34 | 12.800 | 35 | 0.036 | 35 |
| 0.075 | 34 | 0.410 | 34 | 456.333 | 34 | 14.878 | 34 | 12.900 | 34 | 0.037 | 34 |
| 0.076 | 33 | 0.410 | 34 | 456.333 | 34 | 15.483 | 34 | 13.000 | 32 | 0.038 | 34 |
| 0.076 | 33 | 0.420 | 33 | 456.833 | 33 | 15.667 | 33 | 13.000 | 32 | 0.039 | 33 |
| 0.076 | 33 | 0.440 | 32 | 457.333 | 33 | 15.800 | 33 | 13.000 | 32 | 0.040 | 33 |
| 0.078 | 33 | 0.440 | 32 | 457.333 | 33 | 16.083 | 33 | 13.000 | 32 | 0.040 | 33 |

TABLE 6
(Page 6)

| Median Total P (mg/l) | Percent Higher | Median Inorg N (mg/l) | Percent Higher | 500-Mean Secchi (inches) | Percent Higher | Mean Chlorophyll a (µg/l) | Percent Higher | 15-Minimum DO (mg/l) | Percent Higher | Median Dissolved (mg/l) | Percent Higher |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.079 | 32 | 0.440 | 32 | 458.000 | 32 | 16.475 | 32 | 13.000 | 32 | 0.042 | 32 |
| 0.087 | 32 | 0.460 | 32 | 458.000 | 32 | 16.579 | 32 | 13.040 | 32 | 0.042 | 31 |
| 0.089 | 31 | 0.475 | 31 | 458.667 | 31 | 16.600 | 31 | 13.200 | 31 | 0.042 | 31 |
| 0.092 | 31 | 0.480 | 29 | 458.750 | 31 | 17.167 | 31 | 13.220 | 31 | 0.044 | 31 |
| 0.092 | 30 | 0.480 | 29 | 458.889 | 30 | 17.600 | 30 | 13.300 | 30 | 0.048 | 30 |
| 0.094 | 30 | 0.480 | 29 | 459.333 | 29 | 18.267 | 30 | 13.400 | 29 | 0.048 | 29 |
| 0.094 | 29 | 0.480 | 29 | 459.333 | 29 | 18.667 | 29 | 13.400 | 29 | 0.048 | 29 |
| 0.107 | 29 | 0.480 | 28 | 459.555 | 29 | 18.867 | 29 | 13.600 | 27 | 0.049 | 29 |
| 0.108 | 28 | 0.480 | 28 | 460.000 | 28 | 19.259 | 28 | 13.600 | 27 | 0.051 | 28 |
| 0.111 | 27 | 0.485 | 28 | 460.667 | 28 | 19.400 | 28 | 13.600 | 27 | 0.053 | 28 |
| 0.111 | 27 | 0.490 | 27 | 461.333 | 27 | 19.467 | 27 | 13.600 | 27 | 0.055 | 27 |
| 0.115 | 27 | 0.500 | 26 | 461.667 | 27 | 20.311 | 27 | 14.000 | 26 | 0.057 | 27 |
| 0.116 | 26 | 0.500 | 26 | 462.667 | 26 | 20.517 | 26 | 14.000 | 26 | 0.059 | 26 |
| 0.122 | 26 | 0.510 | 26 | 463.333 | 26 | 21.433 | 26 | 14.020 | 26 | 0.060 | 26 |
| 0.124 | 25 | 0.510 | 25 | 464.000 | 25 | 21.783 | 25 | 14.100 | 25 | 0.061 | 25 |
| 0.125 | 25 | 0.520 | 25 | 465.167 | 25 | 21.800 | 25 | 14.160 | 25 | 0.063 | 25 |
| 0.133 | 24 | 0.530 | 24 | 465.250 | 24 | 22.917 | 24 | 14.200 | 24 | 0.068 | 24 |
| 0.135 | 24 | 0.535 | 24 | 465.333 | 23 | 25.300 | 24 | 14.200 | 24 | 0.074 | 24 |
| 0.136 | 23 | 0.550 | 23 | 465.333 | 23 | 25.383 | 23 | 14.400 | 22 | 0.078 | 23 |
| 0.141 | 22 | 0.560 | 23 | 466.167 | 23 | 25.456 | 23 | 14.400 | 22 | 0.081 | 23 |
| 0.141 | 22 | 0.570 | 22 | 466.625 | 22 | 25.600 | 22 | 14.400 | 22 | 0.111 | 22 |
| 0.159 | 22 | 0.570 | 22 | 467.000 | 22 | 27.217 | 22 | 14.400 | 22 | 0.117 | 22 |
| 0.159 | 22 | 0.580 | 22 | 468.000 | 20 | 27.783 | 22 | 14.400 | 22 | 0.126 | 22 |
| 0.171 | 21 | 0.580 | 21 | 468.000 | 20 | 27.800 | 21 | 14.440 | 21 | 0.126 | 21 |
| 0.176 | 21 | 0.590 | 21 | 468.000 | 20 | 28.262 | 21 | 14.500 | 21 | 0.128 | 21 |
| 0.181 | 20 | 0.605 | 20 | 468.000 | 20 | 28.322 | 20 | 14.600 | 15 | 0.134 | 20 |
| 0.185 | 19 | 0.640 | 20 | 468.222 | 20 | 28.333 | 20 | 14.600 | 15 | 0.138 | 20 |
| 0.185 | 19 | 0.645 | 19 | 468.800 | 19 | 28.500 | 19 | 14.600 | 15 | 0.140 | 19 |

TABLE 6
(Page 7)

| Median Total P (mg/l) | Percent Higher | Median Inorg N (mg/l) | Percent Higher | 500-Mean Secchi (inches) | Percent Higher | Mean Chlorophyll a (µg/l) | Percent Higher | 15-Minimum DO (mg/l) | Percent Higher | Median Dissolved P (mg/l) | Percent Higher |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.190 | 19 | 0.660 | 18 | 469.000 | 19 | 28.667 | 19 | 14.600 | 15 | 0.140 | 19 |
| 0.192 | 18 | 0.660 | 18 | 469.200 | 18 | 30.167 | 18 | 14.600 | 15 | 0.141 | 18 |
| 0.209 | 18 | 0.670 | 18 | 469.889 | 18 | 30.800 | 18 | 14.600 | 15 | 0.145 | 18 |
| 0.210 | 17 | 0.680 | 17 | 470.000 | 17 | 30.878 | 17 | 14.600 | 15 | 0.150 | 17 |
| 0.216 | 17 | 0.700 | 17 | 470.200 | 17 | 31.180 | 17 | 14.600 | 15 | 0.153 | 17 |
| 0.231 | 16 | 0.710 | 16 | 470.222 | 16 | 31.367 | 16 | 14.600 | 15 | 0.156 | 16 |
| 0.237 | 16 | 0.740 | 16 | 471.333 | 16 | 33.944 | 16 | 14.600 | 15 | 0.160 | 16 |
| 0.240 | 15 | 0.780 | 15 | 472.000 | 15 | 35.467 | 15 | 14.600 | 15 | 0.161 | 15 |
| 0.240 | 15 | 0.795 | 15 | 472.111 | 15 | 35.820 | 15 | 14.700 | 13 | 0.168 | 15 |
| 0.269 | 14 | 0.815 | 14 | 473.000 | 14 | 36.100 | 14 | 14.700 | 13 | 0.171 | 14 |
| 0.274 | 14 | 0.815 | 14 | 474.000 | 13 | 36.400 | 14 | 14.700 | 13 | 0.189 | 14 |
| 0.286 | 13 | 0.820 | 13 | 474.000 | 13 | 38.083 | 13 | 14.700 | 13 | 0.207 | 13 |
| 0.295 | 13 | 0.840 | 13 | 476.750 | 13 | 39.317 | 13 | 14.700 | 13 | 0.215 | 13 |
| 0.298 | 12 | 0.850 | 12 | 477.167 | 12 | 41.000 | 12 | 14.740 | 12 | 0.216 | 12 |
| 0.300 | 12 | 0.890 | 12 | 477.333 | 12 | 43.933 | 12 | 14.740 | 12 | 0.218 | 12 |
| 0.330 | 11 | 0.920 | 11 | 477.600 | 11 | 44.233 | 11 | 14.760 | 11 | 0.220 | 11 |
| 0.346 | 11 | 0.940 | 11 | 477.600 | 11 | 44.683 | 11 | 14.800 | 5 | 0.221 | 11 |
| 0.361 | 11 | 0.985 | 11 | 477.609 | 11 | 45.148 | 11 | 14.800 | 5 | 0.235 | 11 |
| 0.363 | 10 | 1.020 | 10 | 477.667 | 10 | 48.300 | 10 | 14.800 | 5 | 0.236 | 10 |
| 0.369 | 10 | 1.075 | 10 | 479.167 | 10 | 49.455 | 10 | 14.800 | 5 | 0.251 | 10 |
| 0.378 | 9 | 1.080 | 9 | 479.667 | 9 | 49.467 | 9 | 14.800 | 5 | 0.282 | 9 |
| 0.385 | 9 | 1.080 | 9 | 480.000 | 8 | 50.567 | 9 | 14.800 | 5 | 0.310 | 9 |
| 0.401 | 8 | 1.090 | 8 | 480.000 | 8 | 51.367 | 8 | 14.800 | 5 | 0.319 | 8 |
| 0.408 | 8 | 1.090 | 8 | 480.400 | 8 | 58.550 | 8 | 14.800 | 5 | 0.321 | 8 |
| 0.417 | 7 | 1.110 | 7 | 481.250 | 7 | 58.767 | 7 | 14.800 | 5 | 0.330 | 7 |
| 0.476 | 7 | 1.160 | 7 | 482.428 | 7 | 61.233 | 7 | 14.800 | 5 | 0.344 | 7 |
| 0.476 | 6 | 1.280 | 6 | 482.667 | 6 | 65.320 | 6 | 14.800 | 5 | 0.353 | 6 |
| 0.488 | 6 | 1.310 | 6 | 483.333 | 6 | 69.037 | 6 | 14.800 | 5 | 0.356 | 6 |

TABLE 6
(Page 8)

| Median Total P (mg/l) | Percent Higher | Median Inorg N (mg/l) | Percent Higher | 500-Mean Secchi (inches) | Percent Higher | Mean Chlorophyll a (µg/l) | Percent Higher | 15-Minimum DO (mg/l) | Percent Higher | Median Dissolved P (mg/l) | Percent Higher |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.535 | 5 | 1.310 | 5 | 485.333 | 5 | 69.467 | 5 | 14.800 | 5 | 0.360 | 5 |
| 0.600 | 5 | 1.410 | 4 | 485.333 | 5 | 75.433 | 5 | 14.800 | 5 | 0.383 | 5 |
| 0.620 | 4 | 1.410 | 4 | 485.500 | 4 | 84.333 | 4 | 14.850 | 4 | 0.416 | 4 |
| 0.919 | 4 | 1.430 | 4 | 486.333 | 4 | 86.400 | 4 | 14.900 | 2 | 0.482 | 4 |
| 0.930 | 3 | 1.460 | 3 | 486.500 | 3 | 87.350 | 3 | 14.900 | 2 | 0.635 | 3 |
| 0.958 | 3 | 1.535 | 3 | 487.667 | 3 | 94.467 | 3 | 14.900 | 2 | 0.670 | 3 |
| 1.000 | 2 | 1.575 | 2 | 488.444 | 2 | 126.100 | 2 | 14.900 | 2 | 0.685 | 2 |
| 1.000 | 2 | 1.600 | 2 | 489.000 | 1 | 132.267 | 2 | 14.900 | 2 | 0.710 | 2 |
| 1.215 | 1 | 1.960 | 1 | 489.000 | 1 | 135.525 | 1 | 14.940 | 1 | 0.765 | 1 |
| 1.380 | 1 | 2.150 | 1 | 490.000 | 1 | 143.533 | 1 | 14.940 | 1 | 0.785 | 1 |
| 1.525 | 0 | 2.515 | 0 | 491.000 | 0 | 198.467 | 0 | 14.960 | 0 | 1.260 | 0 |
| 2.000 | 0 | 2.640 | 0 | 491.500 | 0 | 248.933 | 0 | 14.960 | 0 | 1.350 | 0 |
| 3.660 | 0 | 7.355 | 0 | 492.667 | 0 | 381.200 | 0 | 14.980 | 0 | 3.580 | 0 |

sum of the percentiles for the six parameters would be the Trophic Index Number for the lake of interest.

An example for establishing the Trophic Index Number for Lake X is shown below:

| Parameter | Value for Lake X | Percentile (From Table 6) |
|---|---|---|
| Total P (mg/l) | 0.022 | 72 |
| Dissolved P (mg/l) | 0.010 | 73 |
| Inorganic N (mg/l) | 0.330 | 44 |
| 15-Minimum D.O. (mg/l) | 14.8 | 5 |
| 500-Secchi disc (inches) | 420 | 72 |
| Chlorophyll *a* (µg/l) | 6.5 | 75 |
| Total | | 341 = Trophic Index Number |

From Table 4, it would be concluded that the Trophic Index Number of Lake X (341) would place it well into the eutrophic category with a definite potential for developing nuisance bloom conditions.

It should be noted that Table 6 does not provide percentiles for every parameter level or concentration within the range of lakes included in the data base. This presents no problem because the data base is large enough that selecting the percentile from the next highest or lowest listed concentration does not significantly influence the Trophic Index Number.

There are pristine lakes whose parameter values will be less than the lowest shown in Table 6. In those cases, the proposed Trophic Index would not be sensitive enough to show significant changes anyway and it is suggested that an index number of 600 be arbitrarily assigned. This would indicate extremely high quality, in general, but would not negate the possibility of localized problems in some portion of the lake.

There may also be cases where parameter values will be greater than the maximum values listed in Table 6 for total phosphorus, dissolved phosphorus, inorganic nitrogen, and chlorophyll a. If that occurs for a specific paramter, a percentile of 0 could be used. Lack of sensitivity of the proposed Trophic Index at the lower end of the scale presents no serious problem either since large reductions in nutrient levels would be needed to show a marked improvement in trophic condition.

The application of Survey data to the loading concepts proposed by Vollenweider (in press) was discussed in NES Working Paper No. 23, and phosphorus loading data and the trophic states of 42 phosphorus-limited Survey lakes were plotted on Vollenweider's graph of "permissible" and "dangerous" loading rates. It was concluded that generally there was agreement between the Vollenweider model and the Survey data.

In Figure 1, the same loading data and trophic states are plotted on Vollenweider's graph; and the numerical Trophic Index Numbers from Table 4 as determined by the non-weighted six-parameter percentile method, have been added for comparison. In this case, there appears to be agreement between the trophic ranks and the Vollenweider model, with certain exceptions. At least some of the exceptions are believed to be due to the fact that the existing trophic condition is the result of previous loading rates and not necessarily the existing loading rates. For example, the lake with the trophic rank of 357 plotted at the extreme left and between the "permissible" and "dangerous" lines is one to which

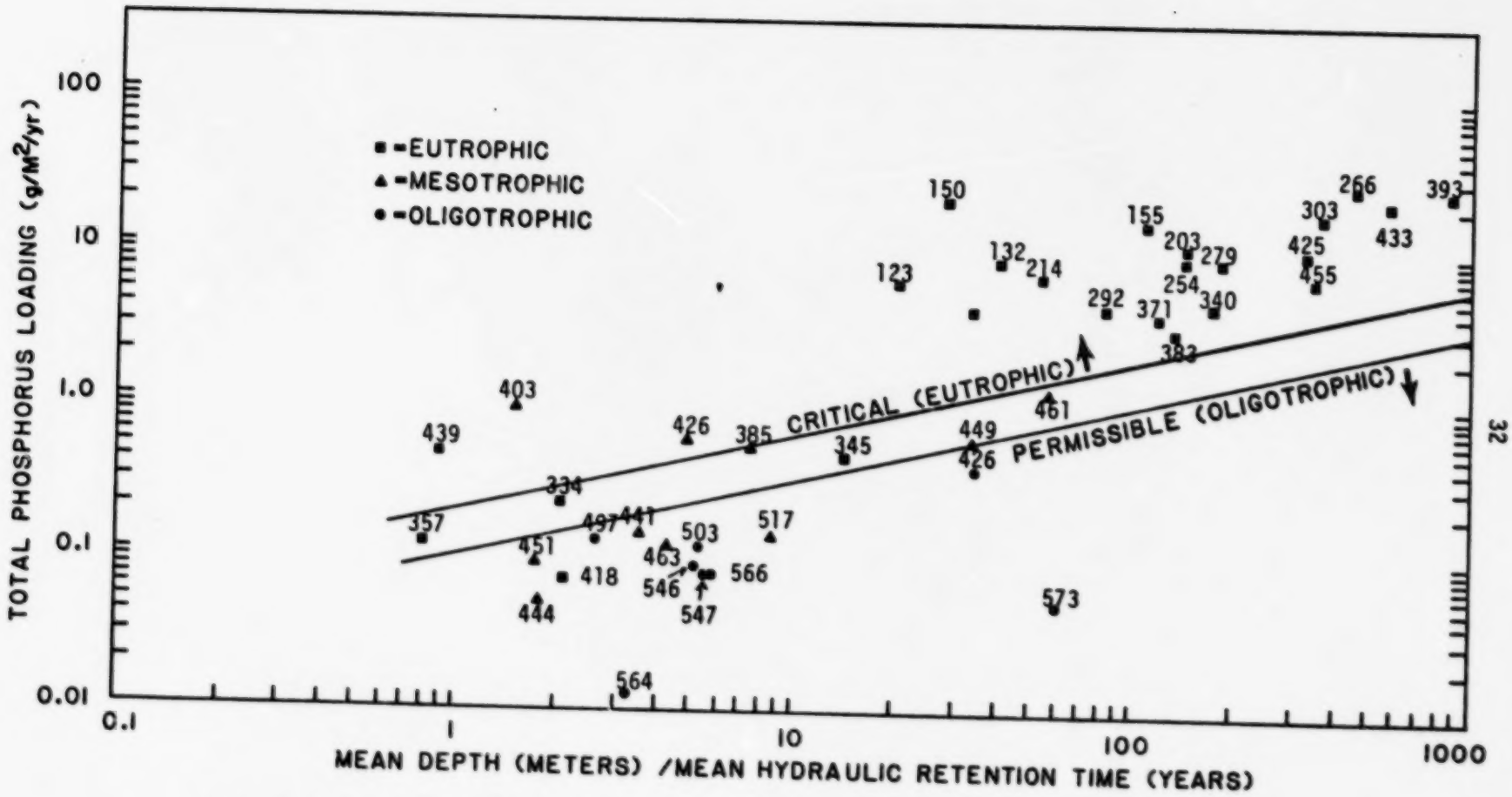


FIGURE 1 THE RELATIONSHIP OF TOTAL PHOSPHORUS LOADING AND LAKE MORPHOMETRY TO TROPHIC CONDITION OF PHOSPHORUS LIMITED LAKES

the loading rate recently has been reduced; however, this lake has a mean hydraulic retention time of eight years, and it will be some time before the trophic condition responds to the reduced loading rate (the model predicts an eventual mesotrophic condition).

## SUMMARY AND CONCLUSIONS

A tentative Trophic State Index was developed in this report using data collected by the National Eutrophication Survey from lakes and reservoirs in the northeast and north-central United States.

In general, the following can be concluded:

1. A Trophic State Index ranging from 0 to 594 and incorporating the parameters of total phosphorus, dissolved phosphorus, inorganic nitrogen, Secchi disc, minimum dissolved oxygen and chlorophyll a was developed which arrayed the 209 lakes and reservoirs in a logical sequence according to their trophic conditions.

2. Using the index cited above, lakes and reservoirs with a Trophic Index Number of 500-594 were oligotrophic while those with an index number of 420-499 were mesotrophic. Below an index number of 420, the lakes became progressively more eutrophic with the lower index numbers corresponding to a higher potential for developing nuisance algal conditions.

3. The Trophic Index Numbers cited in conclusions 1 and 2 are only meaningful when used in conjunction with the data set of 209 lakes and reservoirs presented in this report.

4. Of the 44 lakes and reservoirs included in the National Eutrophication Survey and also cited in "Problem Lakes of the United States" (1971), 40 had a Trophic Index Number (TIN) of less than 420 and 30 had a TIN of less than 299.

5. Lakes or reservoirs in which the trophic problem is primarily aquatic macrophytes, generally do not fit the proposed Trophic Index System; however, this is generally true of all similar index systems.

6. For phosphorus limited lakes, the proposed Trophic Index Numbers corresponded well to Vollenweider's (1973) phosphorus loading-lake morphometry-trophic state relationships which were presented in Working Paper No. 23.

7. The proposed Trophic Index system provides a relative method by which a previously unclassified lake could be classified after the appropriate parameters had been measured. The Trophic Index could also be used to evaluate year to year changes in trophic conditions of a specific lake.

8. The Trophic Index System, as presented, was developed from lakes in northeast and north-central states. Its applicability to lakes and reservoirs in other geographical areas is still questionable.

## LITERATURE REVIEWED

Bartko, John J., Jon S. Strauss, and William T. Carpenter, Jr., 1971. An evaluation of taxonomic techniques for psychiatric data. Classif. Soc. Bull. 2(3), 1-27.

Harkins, Ralph D., 1974. An objective water quality index. Jour. Water Poll. Contr. Fed. 46(3), pt. 1, 588-591.

Ketelle, Martha J., and Paul D. Uttormark, 1971. Problem lakes in the United States. U.S. Environmental Protection Agency, Water Pollution Control Research Series No. 16010 EHR 12/71.

Lueschow, Lloyd A., James M. Helm, Donald R. Winter, and Gary W. Karl; 1970. Trophic nature of selected Wisconsin lakes. Trans. Wisc. Acad. Sci., Arts, & Ltrs, Vol. 58, 237-264.

Padron, Mario, 1969. An axiomatic basis and computational methods for optimal clustering. Techn. Rept. #18, Dept. Indust. & Systems Engr., U. of Florida, 171 pp.

Shannon, Earl E., and Patrick L. Brezonik, 1972. Eutrophication analysis: a multivariate approach. Jour. San. Engr. Divn., Proc. Amer. Soc. Civil Engrs., Febr., 1972, 37-57.

_____, 1972. Relationships between lake trophic state and nitrogen and phosphorus loading rates. Env. Sci. & Techn. 6(8), 719-725.

Sheldon, Andrew L., 1972. A quantitative approach to the classification of inland waters. In: Natural Environments, Studies in Theoretical and Applied Analysis (John V. Krutilla, Ed.), Resources for the Future, Inc. Johns Hopkins U. Press, Baltimore.

Vollenweider, R. A., (in press). Input-output models. Schweizerische Zeitschrift fuer Hydrologie.

Winner, Robert W., 1972. An evaluation of certain indices of eutrophy and maturity in lakes. Hydrobiologia 40(2), 223-245.

# APPENDIX

In the following tabulation, methods and parameter combinations are:

Percentile Method-

#1 = Median total phosphorus, dissolved phosphorus, and inorganic nitrogen; mean chlorophyll *a*; 500 minus the mean Secchi disc depth; and 15 minus the minimum dissolved oxygen.

#2 = All parameters used in #1 plus algal assay control yield.

#3 = Median total phosphorus, inorganic nitrogen, conductivity, and total alkalinity; mean chlorophyll *a*; 500 minus the mean Secchi disc depth; and the algal assay control yield.

#4 = All parameters used in #3 except the median total alkalinity.

#5 = All parameters used in #3 except the median total alkalinity and the algal assay control yield.

#6 = Median total phosphorus and inorganic nitrogen; mean chlorophyll *a*; 500 minus the mean Secchi disc depth; and the algal assay control yield.

#7 = Median total phosphorus and inorganic nitrogen; mean chlorophyll *a*; and 500 minus the mean Secchi disc depth.

Multivariate Analysis (Harkins, 1974)-

H-1 = Mean total phosphorus, dissolved phosphorus, inorganic nitrogen, chlorophyll *a*, and conductivity; 500 minus the mean Secchi disc depth; 15 minus the minimum dissolved oxygen; and the algal assay control yield.

H-2 = Median total phosphorus, dissolved phosphorus, and inorganic nitrogen; mean chlorophyll *a*; 500 minus the mean Secchi disc depth; and 15 minus the minimum dissolved oxygen (note that these are the same parameters used in percentile method, combination #1).

## LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | TROPHIC CONDITION | LAKE NAME | INDEX NO. #1 | #2 | #3 | #4 | #5 | #6 | #7 | H-1 | H-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2314 | O | Bay of Naples | 573 | 2 | 3 | 3 | 3 | 4 | 4 | 2 | 1 |
| 2 | 2311 | O | Sebago Lake | 566 | 1 | 4 | 4 | 5 | 5 | 6 | 1 | 5 |
| 3 | 3303 | O | Lake Winnipesaukee | 564 | 3 | 1 | 1 | 2 | 2 | 3 | 3 | 2 |
| 4 | 5571 | O | Crystal Lake | 549 | 5 | 2 | 2 | 1 | 3 | 2 | 6 | 6 |
| 5 | 2309 | O | Moosehead Lake | 547 | 8 | 8 | 10 | 7 | 11 | 10 | 7 | 8 |
| 6 | 2310 | O | Rangeley Lake | 546 | 7 | 6 | 6 | 4 | 7 | 7 | 5 | 4 |
| 7 | 2695 | O | Higgins Lake | 542 | 4 | 12 | 8 | 10 | 1 | 1 | 25 | 9 |
| 8 | 3634 | O | Schroon Lake | 541 | 6 | 5 | 5 | 9 | 6 | 9 | 4 | 7 |
| 9 | 26A2 | M | Boardman Hydro Pond | 525 | 9 | 30 | 23 | 26 | 14 | 16 | 15 | 11 |
| 10 | 2306 | M | Long Lake | 517 | 10 | 7 | 7 | 6 | 9 | 8 | 8 | 10 |
| 11 | 5572 | M | Trout Lake | 507 | 14 | 9 | 9 | 8 | 8 | 5 | 13 | 15 |
| 12 | 2617 | O | Lake Charlevoix | 503 | 11 | 25 | 16 | 20 | 10 | 12 | 16 | 14 |
| 13 | 3604 | O-M | Canandaigua Lake | 497 | 12 | 32 | 29 | 34 | 23 | 32 | 28 | 23 |
| 14 | 3619 | M | Long Lake | 496 | 13 | 10 | 11 | 11 | 16 | 17 | 9 | 12 |
| 15 | 3617 | M | Keuka Lake | 493 | 16 | 47 | 51 | 31 | 32 | 31 | 19 | 16 |
| 16 | 2704* | M-E | Badger Lake | 487 | 17 | 56 | 39 | 49 | 21 | 23 | 34 | 13 |
| 17 | 3629 | M | Raquette Pond | 486 | 18 | 16 | 18 | 18 | 31 | 34 | 12 | 18 |
| 18 | 3635 | M | Seneca Lake | 482 | 15 | 59 | 65 | 75 | 30 | 37 | 56 | 24 |
| 19 | 3606 | M | Carry Falls Reservoir | 471 | 19 | 17 | 21 | 19 | 34 | 35 | 11 | 21 |
| 20 | 27B0 | M | White Bear Lake | 464 | 23 | 23 | 20 | 17 | 13 | 13 | 51 | 57 |
| 21 | 2313 | M | Long Lake | 463 | 20 | 18 | 17 | 21 | 26 | 33 | 10 | 17 |
| 22 | 5011 | M | Waterbury Reservoir | 461 | 21 | 14 | 14 | 16 | 20 | 27 | 17 | 27 |
| 23 | 2694 | M | Crystal Lake | 459 | 22 | 26 | 22 | 24 | 12 | 15 | 30 | 29 |
| 24 | 2771 | M | Rabbit Lake | 457 | 31 | 40 | 37 | 33 | 38 | 30 | 72 | 69 |
| 25 | 5002** | E | Clyde Pond | 455 | 25 | 33 | 35 | 43 | 51 | 56 | 14 | 20 |
| 26 | 5561 | M | Lake Geneva | 453 | 27 | 44 | 25 | 27 | 15 | 14 | 47 | 36 |
| 27 | 5005 | M | Harriman Reservoir | 452 | 24 | 11 | 12 | 13 | 17 | 21 | 20 | 35 |
| 28 | 5564 | M | Rock Lake | 451 | 28 | 72 | 47 | 57 | 37 | 39 | 32 | 19 |

* Weeds
** Short Detention

## LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | TROPHIC CONDITION | LAKE NAME | INDEX NO. #1 | #2 | #3 | #4 | #5 | #6 | #7 | H-1 | H-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 27B2 | M | Green Lake | 451 | 32 | 49 | 33 | 30 | 35 | 18 | 61 | 25 |
| 30 | 2308 | M | Mattawamkeag Lake | 449 | 30 | 15 | 15 | 14 | 24 | 22 | 24 | 34 |
| 31 | 3632 | M | Sacandaga Reservoir | 444 | 26 | 13 | 13 | 15 | 19 | 26 | 23 | 39 |
| 32 | 2696 | M | Houghton Lake | 444 | 29 | 34 | 34 | 39 | 39 | 45 | 18 | 22 |
| 33 | 2789 | M | Lake Carlos | 441 | 35 | 58 | 32 | 32 | 25 | 19 | 39 | 33 |
| 34 | 5008 | (E) | Lake Memphremagog | 439 | 41 | 54 | 68 | 50 | 71 | 69 | 33 | 30 |
| 35 | 5007** | E | Lamoille Lake | 433 | 40 | 39 | 50 | 42 | 61 | 61 | 26 | 32 |
| 36 | 3627 | M-E | Owasco Lake | 431 | 34 | 68 | 70 | 77 | 63 | 76 | 49 | 59 |
| 37 | 2788 | M | Swan Lake | 431 | 44 | 19 | 19 | 12 | 18 | 11 | 42 | 45 |
| 38 | 3608* | M | Lake Cayuga | 426 | 33 | 71 | 73 | 85 | 42 | 58 | 60 | 54 |
| 39 | 5560* | E | Browns Lake | 425 | 39 | 73 | 67 | 68 | 43 | 42 | 43 | 26 |
| 40 | 5010** | E | Lake Arrowhead | 425 | 36 | 31 | 41 | 51 | 57 | 65 | 21 | 31 |
| 41 | 2730 | M | Fall Lake | 425 | 42 | 20 | 27 | 25 | 52 | 46 | 22 | 28 |
| 42 | 2746 | M | Leech Lake | 422 | 38 | 36 | 26 | 28 | 28 | 25 | 36 | 43 |
| 43 | 5563* | E | Lac La Belle | 420 | 37 | 79 | 65 | 70 | 40 | 48 | 46 | 38 |
| 44 | 2610** | E | Betsie Lake | 419 | 52 | 93 | 86 | 78 | 81 | 73 | 54 | 44 |
| 45 | 5539* | E | Shawano Lake | 418 | 43 | 42 | 43 | 45 | 49 | 49 | 29 | 37 |
| 46 | 3639* | E | Conesus Lake | 418 | 45 | 41 | 36 | 35 | 33 | 28 | 48 | 42 |
| 47 | 2710 | E | Birch Lake | 416 | 47 | 28 | 24 | 22 | 29 | 20 | 40 | +/ |
| 48 | 5536* | E | Pine Lake | 412 | 49 | 62 | 49 | 47 | 44 | 40 | 35 | 40 |
| 49 | 5532* | E | Oconomowoc Lake | 403 | 46 | 69 | 40 | 50 | 22 | 24 | 80 | 64 |
| 50 | 5519 | M | Green Lake | 403 | 50 | 67 | 44 | 41 | 35 | 29 | 62 | 53 |
| 51 | 3636 | E | Swan Lake | 403 | 57 | 38 | 61 | 40 | 78 | 66 | 37 | 41 |
| 52 | 5569* | M-E | Middle Lake | 397 | 48 | 81 | 53 | 64 | 36 | 41 | 91 | 93 |
| 53 | 3306** | E | Kelly Falls Pond | 393 | 51 | 22 | 30 | 29 | 48 | 50 | 27 | 46 |
| 54 | 3610 | E | Chautauqua Lake | 391 | 67 | 57 | 69 | 52 | 76 | 62 | 52 | 49 |
| 55 | 3615 | E | Huntington Lake | 390 | 58 | 21 | 28 | 23 | 45 | 36 | 59 | 58 |
| 56 | 2672** | E | Rogers Pond | 387 | 65 | 90 | 79 | 72 | 69 | 59 | 57 | 48 |

* Weeds
** Short Detention

## LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | TROPHIC CONDITION | LAKE NAME | INDEX NO. #1 | #2 | #3 | #4 | #5 | #6 | #7 | H-1 | H-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 | 5001 | M | Champlain Lake | 385 | 56 | 45 | 55 | 37 | 58 | 53 | 38 | 52 |
| 58 | 3302** | E | Powder Mill Pond | 383 | 53 | 27 | 38 | 48 | 62 | 75 | 31 | 50 |
| 59 | 27B4 | E | Darling Lake | 380 | 54 | 91 | 71 | 73 | 56 | 54 | 79 | 82 |
| 60 | 3633 | E | Saratoga Lake | 373 | 79 | 64 | 74 | 53 | 72 | 51 | 67 | 60 |
| 61 | 5558* | E | Okauchee Lake | 372 | 74 | 113 | 92 | 87 | 77 | 70 | 75 | 62 |
| 62 | 2761 | E | Minnewaska Lake | 372 | 59 | 110 | 84 | 94 | 59 | 63 | 77 | 53 |
| 63 | 2674** | E | Sanford Lake | 371 | 60 | 107 | 96 | 109 | 82 | 85 | 69 | 63 |
| 64 | 5566 | E | Round Lake | 370 | 55 | 66 | 57 | 66 | 47 | 52 | 93 | 97 |
| 65 | 3602 | E | Black Lake | 368 | 64 | 50 | 66 | 65 | 75 | 79 | 41 | 56 |
| 66 | 2793 | E | Trout Lake | 367 | 68 | 51 | 52 | 46 | 41 | 38 | 63 | 74 |
| 67 | 2649** | E | Manistee Lake | 365 | 66 | 102 | 91 | 103 | 68 | 71 | 88 | 61 |
| 68 | 2715 | M | Cass Lake | 364 | 62 | 61 | 46 | 54 | 46 | 43 | 66 | 75 |
| 69 | 2737 | E | Gull Lake | 358 | 77 | 60 | 63 | 55 | 66 | 57 | 76 | 86 |
| 70 | 27B5 | E | Lake Le Homme Dieu | 357 | 61 | 76 | 60 | 69 | 54 | 60 | 74 | 85 |
| 71 | 3640 | E | Lower St. Regis | 355 | 70 | 29 | 42 | 44 | 65 | 72 | 53 | 71 |
| 72 | 2745 | E | Lake of the Woods | 353 | 76 | 74 | 81 | 83 | 90 | 93 | 55 | 68 |
| 73 | 3625 | E | Otter Lake | 352 | 73 | 105 | 101 | 112 | 98 | 109 | 78 | 73 |
| 74 | 3613 | E | Goodyear Lake | 352 | 71 | 53 | 58 | 67 | 60 | 67 | 50 | 65 |
| 75 | 27A9* | E | Forest Lake | 350 | 69 | 52 | 48 | 60 | 50 | 55 | 68 | 81 |
| 76 | 2751 | E | Menomin Lake | 347 | 83 | 78 | 75 | 62 | 64 | 47 | 82 | 77 |
| 77 | 5574 | E | Willow Reservoir | 345 | 63 | 35 | 45 | 63 | 67 | 83 | 44 | 70 |
| 78 | 27C1 | E | Lake Bemidji | 344 | 78 | 70 | 54 | 56 | 53 | 44 | 71 | 76 |
| 79 | 2711 | E | Blackduck Lake | 342 | 81 | 94 | 89 | 92 | 89 | 90 | 58 | 66 |
| 80 | 4402** | E | Slatersville Reservoir | 340 | 72 | 37 | 64 | 74 | 80 | 89 | 45 | 67 |
| 81 | 2698 | E | Pere Marquette Lake | 336 | 91 | 125 | 119 | 114 | 104 | 96 | 90 | 72 |
| 82 | 2688 | E | White Lake | 334 | 89 | 108 | 98 | 93 | 83 | 77 | 87 | 79 |
| 83 | 2618 | E | Lake Chemung | 334 | 85 | 92 | 85 | 81 | 70 | 64 | 100 | 89 |
| 84 | 0902 | E | Bantam Lake | 332 | 92 | 83 | 90 | 86 | 102 | 99 | 116 | 117 |

* Weeds
** Short Detention

## LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | TROPHIC CONDITION | LAKE NAME | INDEX NO. #1 | #2 | #3 | #4 | #5 | #6 | #7 | H-1 | H-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 85 | 3641 | E | Allegheny Reservoir | 330 | 94 | 98 | 110 | 96 | 113 | 103 | 83 | 80 |
| 86 | 2765 | E | Pelican Lake | 330 | 82 | 43 | 59 | 59 | 73 | 78 | - | 78 |
| 87 | 2673 | E | Ross Reservoir | 330 | 80 | 128 | 111 | 125 | 88 | 101 | 96 | 83 |
| 88 | 3607 | E | Cassadaga Lake | 328 | 93 | 80 | 80 | 71 | 85 | 80 | 86 | 96 |
| 89 | 27C0 | E | Andrusia Lake | 328 | 84 | 84 | 77 | 80 | 79 | 81 | 81 | 84 |
| 90 | 5557 | E | Pewaukee Lake | 327 | 86 | 103 | 88 | 90 | 76 | 74 | 111 | 95 |
| 91 | 3305 | E | Glenn Lake | 327 | 75 | 24 | 31 | 36 | 55 | 68 | 70 | 90 |
| 92 | 0912 | E | Shelton Lake | 326 | 90 | 96 | 100 | 104 | 101 | 100 | 73 | 88 |
| 93 | 5556 | E | Lake Wissota | 324 | 88 | 65 | 78 | 76 | 92 | 88 | 65 | 87 |
| 94 | 5575 | E | Elk Lake | 303 | 95 | 63 | 82 | 79 | 96 | 98 | 92 | 91 |
| 95 | 2509 | E | Rochdale Pond | 303 | 99 | 85 | 105 | 99 | 107 | 106 | 103 | 92 |
| 96 | 2716 | E | Clearwater Lake | 300 | 96 | 106 | 95 | 97 | 86 | 84 | 101 | 100 |
| 97 | 2780 | E | Shagawa Lake | 297 | 100 | 55 | 76 | 61 | 87 | 82 | 107 | 103 |
| 98 | 27B3 | E | Nest Lake | 293 | 101 | 123 | 106 | 106 | 95 | 86 | 106 | 101 |
| 99 | 2312 | E | Sebasticook Lake | 293 | 106 | 99 | 113 | 107 | 119 | 116 | 98 | 104 |
| 100 | 5573 | E | Long Lake | 292 | 87 | 48 | 72 | 84 | 84 | 102 | 64 | 98 |
| 101 | 5550 | E | Wapogasset Lake | 291 | 105 | 97 | 99 | 91 | 103 | 95 | 94 | 94 |
| 102 | 5576 | E | Yellow Lake | 286 | 102 | 88 | 93 | 89 | 97 | 94 | 89 | 99 |
| 103 | 2712 | E | Blackhoof Lake | 279 | 108 | 95 | 97 | 88 | 100 | 87 | 121 | 110 |
| 104 | 2685 | E | Union Lake | 279 | 103 | 152 | 130 | 152 | 122 | 131 | 120 | 102 |
| 105 | 2621 | E | Constantine Reservoir | 273 | 114 | 167 | 156 | 161 | 141 | 143 | 128 | 115 |
| 106 | 26A0 | E | Holloway Reservoir | 271 | 115 | 158 | 144 | 144 | 124 | 122 | 127 | 106 |
| 107 | 0904 | E | Eagleville Lake | 271 | 112 | 86 | 107 | 101 | 117 | 117 | 99 | 111 |
| 108 | 5551 | E | Lake Wausau | 266 | 104 | 82 | 94 | 105 | 105 | 118 | 95 | 118 |
| 109 | 3630 | E | Round Lake | 266 | 123 | 138 | 143 | 135 | 148 | 135 | 143 | 150 |
| 110 | 2697 | E | Thompson Lake | 266 | 109 | 126 | 115 | 115 | 94 | 92 | 109 | 107 |
| 111 | 5562 | E | Lake Como | 265 | 97 | 144 | 140 | 168 | 132 | 167 | 119 | 128 |
| 112 | 27A7 | E | St. Croix Lake | 264 | 111 | 100 | 109 | 108 | 114 | 119 | 85 | 109 |

LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | TROPHIC CONDITION | LAKE NAME | INDEX NO. #1 | #2 | #3 | #4 | #5 | #6 | #7 | H-1 | H-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 113 | 2720 | E | Cranberry Lake | 262 | 98 | 75 | 83 | 95 | 91 | 107 | 97 | 113 |
| 114 | 2665 | E | Pentwater Lake | 259 | 116 | 127 | 120 | 119 | 110 | 110 | 123 | 120 |
| 115 | 27A2 | E | Wolf Lake | 258 | 107 | 112 | 104 | 111 | 99 | 105 | 105 | 112 |
| 116 | 0911 | E | Lillinoah Lake | 258 | 122 | 109 | 112 | 100 | 109 | 97 | 113 | 125 |
| 117 | 2749 | E | Whitewater Lake | 257 | 113 | 77 | 87 | 82 | 93 | 91 | 104 | 116 |
| 118 | 5509 | E | Butternut Lake | 256 | 118 | 87 | 103 | 98 | 112 | 112 | 102 | 114 |
| 119 | 5508 | E | Butte Des Morts | 254 | 120 | 143 | 133 | 142 | 139 | 145 | 112 | 126 |
| 120 | 2683 | E | Thornapple Lake | 254 | 119 | 156 | 138 | 148 | 121 | 126 | 146 | 135 |
| 121 | 5535 | E | Pigeon Lake | 247 | 126 | 134 | 124 | 118 | 118 | 108 | 133 | 123 |
| 122 | 0910 | E | Zoar Lake | 246 | 124 | 119 | 121 | 116 | 125 | 124 | 108 | 119 |
| 123 | 2725 | E | Elbow Lake | 245 | 136 | 137 | 141 | 127 | 142 | 128 | 154 | 149 |
| 124 | 27A1 | E | Winona Lake | 245 | 131 | 162 | 164 | 162 | 164 | 161 | 140 | 136 |
| 125 | 2699 | E | Strawberry Lake | 243 | 133 | 147 | 131 | 128 | 123 | 111 | 164 | 139 |
| 126 | 2760 | E | Lake Minnetonka | 241 | 117 | 120 | 116 | 122 | 106 | 113 | 130 | 122 |
| 127 | 2643 | E | Kent Lake | 237 | 127 | 159 | 152 | 154 | 130 | 133 | 170 | 142 |
| 128 | 2692 | E | Long Lake | 231 | 137 | 148 | 134 | 130 | 126 | 115 | 168 | 148 |
| 129 | 2659 | E | Muskegon Lake | 231 | 128 | 122 | 118 | 113 | 108 | 104 | 118 | 121 |
| 130 | 5538 | E | Poygan Lake | 229 | 132 | 145 | 148 | 151 | 149 | 149 | 125 | 129 |
| 131 | 2786 | E | Superior Bay | 229 | 129 | 117 | 114 | 117 | 120 | 130 | 110 | 133 |
| 132 | 2513 | E | Hudson Impoundment | 225 | 152 | 131 | 142 | 126 | 150 | 132 | 153 | 163 |
| 133 | 2756 | E | Mashkenode Lake | 223 | 125 | 116 | 117 | 124 | 116 | 125 | 126 | 127 |
| 134 | 5548 | E | Town Line Lake | 218 | 130 | 89 | 102 | 102 | 111 | 114 | 117 | 145 |
| 135 | 5546 | E | Tainter Lake | 216 | 149 | 132 | 132 | 129 | 147 | 138 | 129 | 134 |
| 136 | 27B6 | E | Calhoun Lake | 216 | 139 | 140 | 139 | 139 | 127 | 123 | 147 | 144 |
| 137 | 5520 | E | Kegonsa Lake | 214 | 135 | 153 | 146 | 150 | 137 | 139 | 138 | 137 |
| 138 | 3637 | E | Swinging Bridge Reservoir | 214 | 143 | 115 | 127 | 121 | 144 | 141 | 131 | 132 |
| 139 | 2709 | E | Big Stone Lake | 213 | 140 | 170 | 166 | 169 | 143 | 146 | 152 | 130 |

## LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | TROPHIC CONDITION | LAKE NAME | #1 | #2 | #3 | #4 | #5 | #6 | #7 | H-1 | H-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 | 2777 | E | Sakatah Lake | 211 | 150 | 154 | 147 | 141 | 136 | 129 | 145 | 147 |
| 141 | 2693 | E | St. Louis Reservoir | 209 | 155 | 186 | 179 | 170 | 157 | 147 | 178 | 162 |
| 142 | 2705 | E | Bartlett Lake | 208 | 144 | 155 | 159 | 165 | 176 | 182 | 136 | 154 |
| 143 | 5502 | E | Altoona Lake | 207 | 142 | 124 | 129 | 132 | 152 | 152 | 122 | 140 |
| 144 | 5531 | E | Lake Nagawicka | 205 | 158 | 166 | 154 | 146 | 135 | 127 | 165 | 157 |
| 145 | 2792 | E | Trace Lake | 205 | 147 | 171 | 168 | 172 | 166 | 174 | 149 | 160 |
| 146 | 2511 | E | Billerica Impoundment | 204 | 151 | 129 | 135 | 134 | 146 | 142 | 134 | 143 |
| 147 | 2503 | E | Harris Pond | 203 | 141 | 111 | 123 | 123 | 134 | 136 | 135 | 151 |
| 148 | 2304 | E | Estes Lake | 201 | 153 | 114 | 126 | 120 | 140 | 137 | 132 | 141 |
| 149 | 2671 | E | Randall Lake | 199 | 161 | 180 | 181 | 174 | 167 | 159 | 159 | 155 |
| 150 | 2731 | E | Fanny Lake | 196 | 148 | 188 | 177 | 187 | 161 | 175 | 166 | 183 |
| 151 | 5510 | E | Castle Rock Flowage | 193 | 134 | 118 | 125 | 138 | 133 | 153 | 115 | 146 |
| 152 | 26A1 | E | Caro Reservoir | 193 | 138 | 182 | 170 | 189 | 153 | 171 | 150 | 156 |
| 153 | 5545 | E | Swan Lake | 192 | 163 | 151 | 136 | 131 | 128 | 121 | 148 | 158 |
| 154 | 2748 | E | Little Lake | 191 | 162 | 190 | 183 | 178 | 162 | 156 | 182 | 177 |
| 155 | 5503 | E | Beaver Dam Lake | 189 | 159 | 181 | 174 | 173 | 173 | 172 | 163 | 181 |
| 156 | 5534 | E | Petenwell Flowage | 186 | 145 | 121 | 128 | 137 | 138 | 151 | 124 | 152 |
| 157 | 0901 | E | Aspinook Lake | 186 | 164 | 139 | 155 | 153 | 179 | 176 | 141 | 159 |
| 158 | 27C3 | E | Cottonwood Lake | 182 | 157 | 191 | 199 | 206 | 192 | 197 | 175 | 176 |
| 159 | 2609 | E | Belleville Lake | 181 | 169 | 196 | 194 | 193 | 191 | 187 | 176 | 166 |
| 160 | 2796 | E | Tuttle Lake | 180 | 166 | 183 | 187 | 186 | 175 | 173 | 174 | 174 |
| 161 | 2613 | E | Brighton Lake | 180 | 146 | 178 | 169 | 190 | 155 | 185 | 155 | 175 |
| 162 | 0905 | E | Hanover Pond | 178 | 172 | 163 | 182 | 171 | 197 | 191 | 171 | 179 |
| 163 | 5522 | E | Koshkonong Lake | 176 | 171 | 200 | 192 | 184 | 182 | 169 | 180 | 171 |
| 164 | 2752 | E | Malmedal Lake | 176 | 160 | 187 | 186 | 192 | 171 | 186 | 151 | 165 |
| 165 | 5555 | E | Wisconsin Lake | 174 | 167 | 135 | 145 | 143 | 156 | 155 | 139 | 161 |
| 166 | 2719 | E | Cokato Lake | 171 | 175 | 176 | 160 | 155 | 145 | 134 | 181 | 182 |

## LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | TROPHIC CONDITION | LAKE NAME | INDEX NO. #1 | #2 | #3 | #4 | #5 | #6 | #7 | H-1 | H-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 167 | 5554 | E | Lake Winnebago | 170 | 170 | 161 | 163 | 160 | 172 | 166 | 161 | 167 |
| 168 | 2776 | E | St. Louis Bay | 168 | 178 | 136 | 149 | 136 | 160 | 150 | 167 | 196 |
| 169 | 3611 | E | Cross Lake | 167 | 156 | 149 | 153 | 164 | 129 | 140 | 156 | 153 |
| 170 | 5513 | E | Lake Delavan | 165 | 177 | 169 | 165 | 158 | 154 | 144 | 187 | 172 |
| 171 | 2753 | E | Mud Lake at Maple Lake | 162 | 168 | 199 | 191 | 196 | 184 | 192 | 189 | 197 |
| 172 | 2507 | E | Woods Pond | 162 | 182 | 160 | 171 | 159 | 183 | 168 | 162 | 180 |
| 173 | 2750 | E | Madison Lake | 161 | 165 | 146 | 150 | 157 | 151 | 163 | 137 | 164 |
| 174 | 2504 | E | Maynard Impoundment | 160 | 183 | 142 | 157 | 147 | 177 | 158 | 172 | 178 |
| 175 | 2706 | E | Bear Lake | 159 | 154 | 165 | 173 | 194 | 169 | 195 | 160 | 187 |
| 176 | 5565 | E | Big Eau Pleine Reservoir | 158 | 176 | 133 | 151 | 145 | 174 | 170 | 144 | 168 |
| 177 | 2629 | E | Ford Lake | 155 | 180 | 185 | 180 | 175 | 163 | 162 | 173 | 170 |
| 178 | 2606 | E | Barton Lake | 150 | 179 | 168 | 161 | 167 | 159 | 157 | 169 | 173 |
| 179 | 27A4 | E | Lake Pepin | 144 | 174 | 174 | 142 | 182 | 170 | 183 | 158 | 184 |
| 180 | 5515 | E | Eau Claire Lake | 141 | 181 | 130 | 137 | 140 | 158 | 165 | 142 | 169 |
| 181 | 27A6 | E | Spring Lake | 139 | 188 | 203 | 203 | 199 | 200 | 199 | 191 | 191 |
| 182 | 2603 | E | Allegan Lake | 138 | 185 | 201 | 195 | 195 | 188 | 188 | 184 | 185 |
| 183 | 2508 | E | Matfield Impoundment | 137 | 192 | 141 | 158 | 149 | 181 | 164 | 190 | 199 |
| 184 | 27B8 | E | Lost Lake | 134 | 187 | 157 | 167 | 163 | 186 | 179 | 183 | 189 |
| 185 | 2640 | E | Jordan Lake | 133 | 189 | 172 | 172 | 166 | 165 | 154 | 185 | 188 |
| 186 | 5570 | E | Grand Lake | 132 | 186 | 205 | 198 | 200 | 195 | 196 | 192 | 194 |
| 187 | 27A8 | E | Budd Lake | 130 | 184 | 175 | 178 | 180 | 178 | 180 | 186 | 196 |
| 188 | 2616 | E | Irondequoit Bay | 128 | 195 | 208 | 208 | 207 | 204 | 202 | 206 | 211 |
| 189 | 27A5 | E | Zumbro Lake | 126 | 196 | 197 | 189 | 176 | 180 | 160 | 196 | 193 |
| 190 | 2648 | E | Lake Macatawa | 123 | 193 | 192 | 197 | 197 | 196 | 193 | 188 | 190 |
| 191 | 27B1 | E | Wagonga Lake | 122 | 190 | 209 | 207 | 208 | 201 | 204 | 199 | 204 |
| 192 | 2713 | HE | Buffalo Lake | 118 | 191 | 184 | 184 | 179 | 187 | 189 | 179 | 192 |

## LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | TROPHIC CONDITION | LAKE NAME | INDEX NO. #1 | #2 | #3 | #4 | #5 | #6 | #7 | H-1 | H-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 193 | 2691 | HE | Mona Lake | 118 | 197 | 177 | 190 | 183 | 189 | 177 | 197 | 200 |
| 194 | 2782 | HE | Silver Lake | 114 | 198 | 204 | 201 | 201 | 199 | 201 | 193 | 202 |
| 195 | 0903 | HE | Community Lake | 112 | 201 | 179 | 196 | 191 | 205 | 203 | 195 | 201 |
| 196 | 2702 | HE | Albert Lea Lake | 102 | 203 | 210 | 210 | 210 | 208 | 208 | 208 | 208 |
| 197 | 27C2 | HE | Mud Lake | 100 | 202 | 194 | 202 | 198 | 206 | 206 | 205 | 212 |
| 198 | 2714 | HE | Carrigan Lake | 99 | 199 | 202 | 200 | 203 | 194 | 194 | 200 | 206 |
| 199 | 2502 | HE | Hager Pond | 94 | 206 | 198 | 209 | 209 | 209 | 209 | 204 | 210 |
| 200 | 2785 | HE | St. Clair Lake | 93 | 200 | 189 | 185 | 185 | 185 | 190 | 198 | 198 |
| 201 | 4403 | HE | Turner Reservoir | 92 | 204 | 164 | 188 | 177 | 202 | 200 | 194 | 205 |
| 202 | 2631 | HE | Fremont Lake | 92 | 205 | 193 | 193 | 188 | 193 | 184 | 201 | 203 |
| 203 | 5559 | HE | Tichigan Lake | 80 | 207 | 206 | 204 | 204 | 198 | 198 | 207 | 207 |
| 204 | 27A3 | HE | Woodcock Lake | 60 | 208 | 207 | 205 | 205 | 203 | 205 | 202 | 209 |
| 205 | 27B7 | HE | Wallmark Lake | 41 | 209 | 195 | 206 | 202 | 207 | 207 | 203 | 213 |